POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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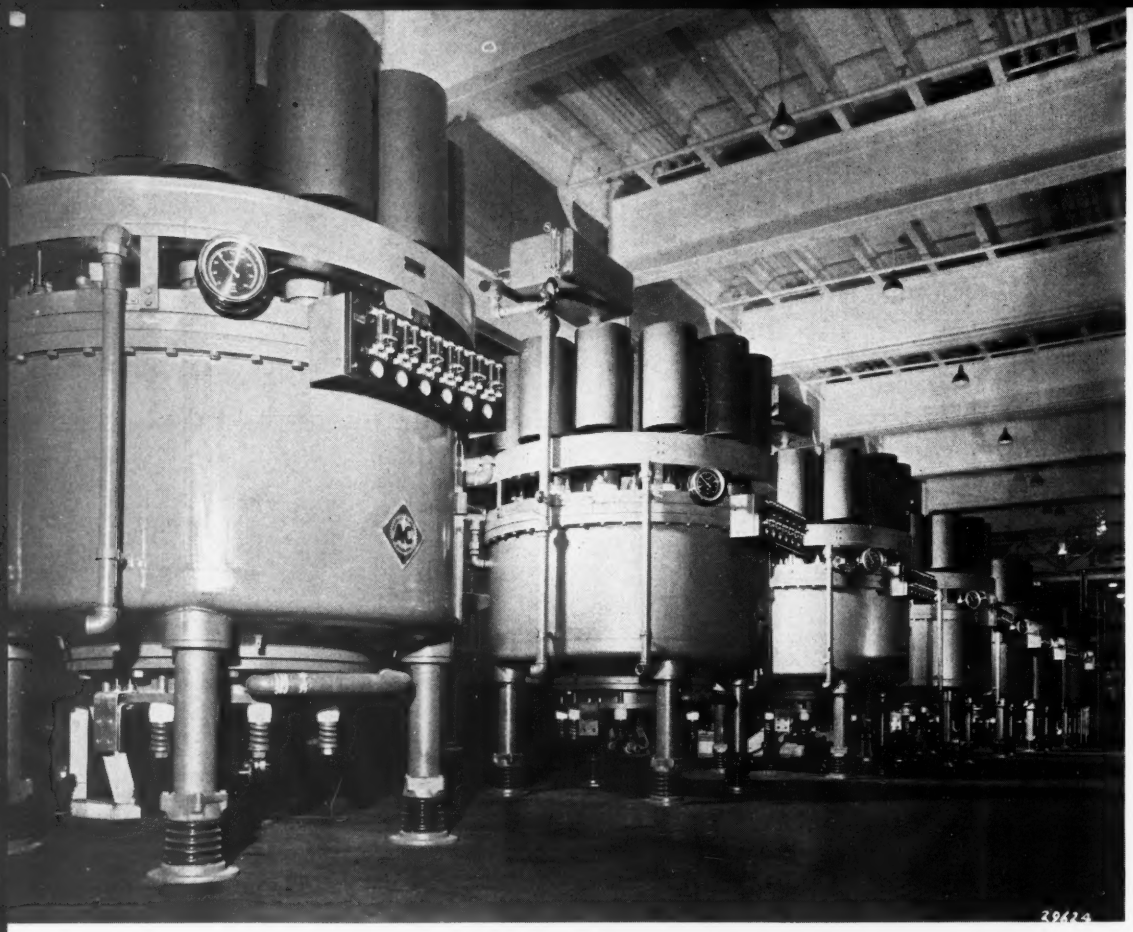


Electronics—And How!

DID the radio service man ever delve into the rat's nest back of your ailing radio receiver and after a period of contemplative rummaging emerge with the startling announcement that the rectifier tube was shot—blown, caput or what have you? If so, no doubt the shock was subsequently dispelled with the reassuring news that this was not a serious matter—something around eighty cents — and after its replacement your radio destroyed the peace of your household quite as effectively as ever.

Judging from one's first impression of the picture shown above, it would not seem that the little rectifying tubes in your radio receiver could have anything in common with the ponderous line up of equipment assembled here, yet they are members of the same family and in the circuit they fulfill the same function. The only real difference between them is a matter of capacity. Whereas the rectifiers in your receiver handle power measured in terms of a few watts, the installation shown above has a capacity of 55,000 kilowatts! Used for supplying direct current in the manufacture of aluminum at the Alcoa, Tennessee works of the Aluminum Co. of America and designed and constructed by the Allis-Chalmers Mfg. Co. This installation of rectifiers constitutes one of the largest concentrations of electronic apparatus in the world.

This installation, indeed, serves as an excellent example, showing how the use of electronic equipment in industry is increasing. Though born in the pre-electronic era of electrical engineering, the mercury arc rectifier is nevertheless a true electronic device and its present day refinements come to it from modern electronic technique in other fields. Today, electron devices often constitute the primary apparatus in the circuits with the circuits built around them. Typical of this type of development are the interesting thyratron motor control circuits described in the article on electron tubes in this issue. In another article (p. 132) we describe how the use of mercury arc rectifiers solved a difficult problem in the relocation of a Baltimore and Ohio R. R. substation.

These examples serve to show how the use of electronic devices is increasing in all directions. From a small gadget associated only with communication a few years ago, the electron tube has grown to units of such ponderous proportions for use in industry as shown here. If you wish to keep abreast of electrical developments do not neglect the field of electronics.

WITH THE EDITORS

Put Records To Work

ACROSS the ledger of every business concern that operates a power or steam plant is a record of expense for which the man in charge of the power plant shares a definite responsibility. It cannot be said, however, that all responsibility for the showing in the record is upon the engineer, for he must deal with many conditions entirely outside his control. Nevertheless, how he manages the plant is written as good or bad in the company's books.

As commonly set up in company organizations, the power engineer's work is partly management, partly technical and, in many instances, skilled labor. Due, however, to the advancements made in equipment design with automatic controls and safety devices, the management phase of an engineer's services is becoming extremely more important. There are, of course, such technical problems as the selection of the proper fuel for the plant, the best method of meeting the changes in load conditions by a program of operation satisfactory to the industry he serves, the choice of proper pressures, the treatment of water, lubricating problems, and a thousand and one other questions that, to make a correct decision, require a technical knowledge of engineering principles. From an economic standpoint, however, the most important work of the engineer is to get things done as he desires them and as quickly as the need indicates. This is strictly a question of management.

Of greatest aid to the engineer in all phases of his work are carefully kept and adequate records dealing with all costs that affect the power plant, principal operating conditions of plant equipment and a history of each important piece of equipment in the plant detailing its service, upkeep expense and repairs and all changes in design or hookup. When accurately kept, and up to date, these records permit an interpretation which will point to improvements that are otherwise impossible to observe.

Engineers have found that a monthly check of operation results and conditions against the calculated theoretical heat balance is one of the most helpful methods of building up the efficiency of a plant, and this, of course, requires a rather full operating record. The heat balance should be sufficiently complete to point to all important places where changes in energy form may result in losses, also where changes in pressure, temperature and amounts of flow take place.

That records will pay handsome dividends, if properly put to work, was indicated recently in three different instances. One in which an investment in extra boiler capacity amounting to many thousands of dollars was averted by the simple expedient of avoiding an excessive heating-load peak by judiciously advancing the time of service to buildings. The second plant cut its annual coal bill by over 30 per cent by improving combustion conditions and good housekeeping consisting in stopping leaks, repairing traps, replacing damaged pipe covering, remodeling pipe connections and in general attending promptly to needed repairs. The third was a case where purchased power peak demands were graphically recorded and reduced by adopting a suitable program of operation.

Operating records in the vault are as useless as ice at the North Pole, but when the data are used by a competent engineer immediately after they are secured, even in the smallest plants, the cost of preparing them will be repaid with dividends, safety will be heightened and services improved.

An Impending Breakdown

IT MAY not be realized by the owner of a power plant that equipment in that plant is 10, 15, even 20 or more years old, and still being depended upon to serve his factory or building. If his is an average plant he has added almost no new equipment in the last 10 yr. During that 10 yr. the wear and tear on operating equipment has taken its natural toll on all bearings and rubbing surfaces; ferrous materials have rusted and other metallic materials tarnished or corroded to a condition that they no longer function with the perfection they once did; wooden parts, plastics, parts made of fabric, brick and cement work, in fact all materials are subject to deterioration even when not in the actual service of turning out power.

By every known expedient, engineers have been keeping a surprising number of these plants in a running condition, but the time comes when the owner is forced to install new equipment as the only safe solution to the power and heat supply problem. So many improvements have been made in every phase of power plant design from the materials used and operating practice, to the fundamental heat balance, that many opportunities are now available for reducing service costs that were little known or nonexistent at the time the 20-yr.-old plant was first put into operation.

It cannot be too strongly emphasized that old worn out power equipment is not only far behind in economy of operation but an impending danger to the building and neighborhood in which it operates. Rehabilitation programs are no longer economical in the majority of American plants; the time has come to modernize completely or build entirely new plants employing the latest approved practices.

South Meadow's New 40,000 Kw.

BY WILLIAM F. RYAN
Mechanical Engineer,
Stone & Webster Engineering Corp.

THE LATEST addition to the South Meadow Station of The Hartford Electric Light Co. went into commercial operation during October, 1938. The extension includes one 400,000 lb. per hr. coal and oil fired boiler and one 40,000-kw. condensing turbine generator, operating at 850 lb. gage pressure and 900 deg. F. total temperature at the turbine throttle. This extension brings the total rated capacity of the station to 130,000 kw. at 80 per cent power factor and like the original station, was designed and built by Stone & Webster Engineering Corporation, under the personal supervision of Mr. T. H. Soren, Vice President of The Hartford Electric Light Company.

The first turbine generator installed at South Meadow was a 20,000-kw. unit and was completed in 1921. A second 20,000-kw. unit was completed in 1923. The plant at that time contained four stoker fired boilers operating at 256 lb. gage and 656° F. total steam temperature. One of these boilers has since been converted to oil firing. In 1928 the steam turbines were "topped" by a 10,000-kw. mercury boiler and turbine, the design of which was based on a previous mercury installation at the Dutch Point Station of the same company. The latter was perhaps the earliest topping installation in an American central station. This 10,000-kw. mercury unit has been highly satisfactory, both with respect to efficiency and service availability, but the design of the boiler is not applicable to the larger capacities now required, and it was felt that further mercury topping at South Meadow should await improvements and development of the more recent designs of larger equipment.

In 1929 a 40,000-kw. condensing extraction turbine generator was installed in space which had been provided for a third 20,000 kw. unit. This turbine was operated initially at the same pressure as the older boilers, but was designed for a throttle pressure of 375 lb. gage and a total temperature of 700 deg. F., and has been operated at that pressure and temperature since the installation in 1930 of a boiler designed for 450 lb. pressure and fired by pulverized coal and oil fuel. The steam generating mercury condenser had been designed to produce steam either at 375 lb. gage or 256 lb. gage so that the mercury plant can be used to "top" any of the three steam turbine generators previously installed.

For the 1938 extension, studies were made of higher and lower steam pressures than the 850 lb. finally adopted. Also, an analysis was made of the relative installation and operating costs of steam "topping" for the existing 256 lb. turbines and a new high pressure condensing unit. The latter showed a much lower installation cost per kilowatt of additional capacity and, including capital charges, a lower cost per kilowatt-hour of additional output. For a condensing unit, the fuel saving which might have been obtained from an initial pressure higher than 850 lb. gage was not commensurate with the additional installation cost.

Figure 2 shows a cross section of the 1938 extension. The boiler is a Babcock & Wilcox Company cross drum unit with a completely water-cooled furnace. As shown in the cross section, the boiler has two straight through gas passages with the superheater in the forward lane and the greater portion of the economizer in the rear. Superheat is regulated by the adjustment of dampers at the top of the two lanes, throwing more gas through the superheater to raise the steam temperature, or more through the economizer lane when the superheat is high. The furnace is hopper bottomed, designed to deliver dry ash to the sluicing system when coal is used for fuel.

The design pressure of the boiler is 950 lb. gage. The normal continuous capacity of the steam generating unit is 400,000 lb. per hr. when producing steam at 875 lb. gage and 915 deg. F. at the superheater outlet from feedwater entering the economizer at 350 deg. F. The guaranteed maximum capacity is 425,000 lb. per hr. under the same conditions and this capacity is obtainable with either pulverized coal or oil fuel. Fans, pulverizers, feedwater pumps and all auxiliaries are designed to maintain this higher rate of output continuously. The maximum flow to the main turbine, under any condition of operation, is 405,000 lb. per hr. The boiler has sufficient capacity to maintain this flow and, at the same time, supply the full load requirements of the emergency steam driven boiler feed pump and the steam jet vacuum pumps. Under average operating conditions, with a load of 40.000 kw. on the new turbine generator, and with circulating water supplied to the condenser at or below 70 deg. F., the steam consumption of the new turbine will not exceed 350.000 lb. per hr. Ordinarily, therefore, there will be surplus steam capacity in the new steam generating unit which can be used

Extension

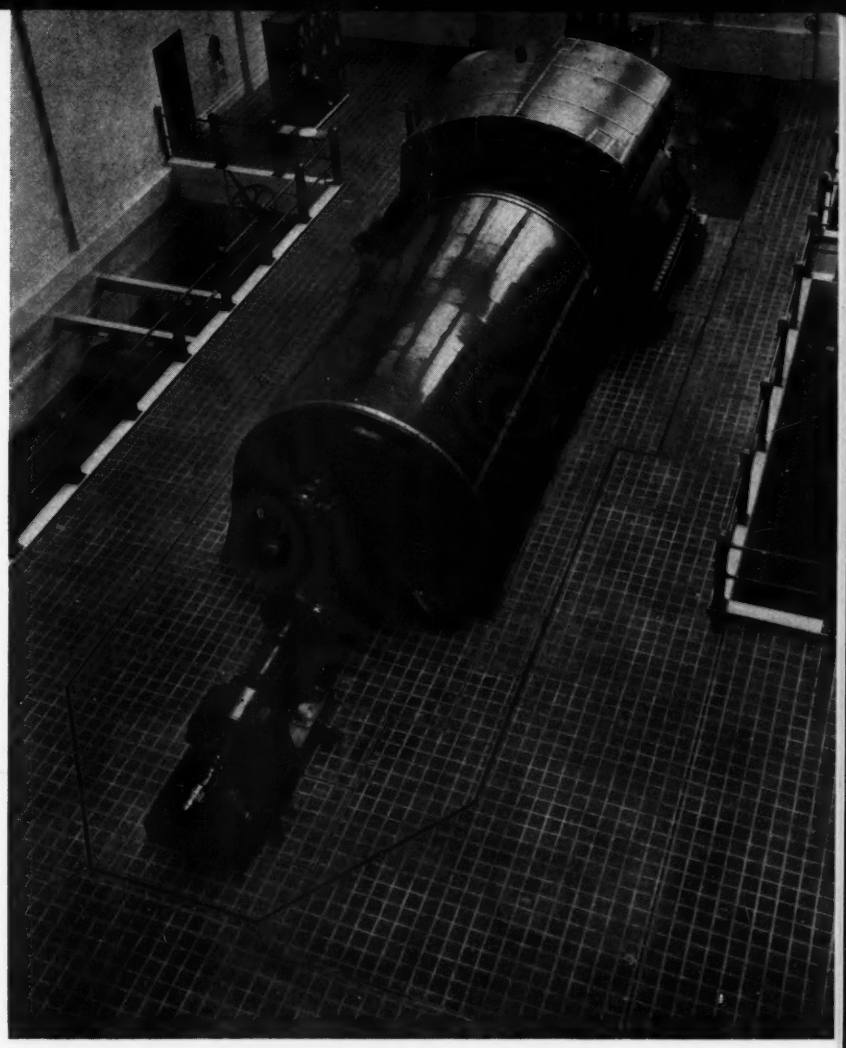


Fig. 1
The Turbine Generator

in the older sections of the plant after passing through a reducing valve and desuperheater.

As shown by the cross section, the gas flow is directly upward, through the boiler, superheater and economizer, and through twin regenerative type air preheaters to the induced draft fans which discharge upward to the superimposed steel, brick-lined stack. This direct flow, continuously upward, requires a minimum of duct work, and the friction loss is unusually low. Air flow is equally direct. Each of the two forced draft fans discharges downward through one of the air preheaters, and down each side of the boiler setting to the burner windbox; there is no cross connection of the air ducts except the burner windbox itself.

The fans are combination units, one forced draft fan and one induced draft fan mounted on a single shaft. Each pair of fans is driven by a constant speed motor through a hydraulic coupling which permits smooth and accurate speed regulation from 20 to 98 per cent of the full load motor speed which is 705 r.p.m. The draft system is designed for operation with one fan unit and one air preheater at light load; either fan set has sufficient capacity to operate the boiler at an output of 250,000 lb. per hr. The compactness of the fans and drives is shown by the photograph, Fig. 5.

The Peabody combination burners are designed for separate or simultaneous use of pulverized coal and fuel oil. Each of the four Riley pulverizers has a capacity of 10,000 to 12,500 lb. of coal per hr., depending on the quality and dryness of the coal. Storage hoppers above the pulverizer feeders are filled from the same larry that supplies coal to the adjacent 450 lb. boiler installed in 1930. Each pulverizer discharges upward inside the burner windbox to two of the eight burners. This arrangement frees the firing aisle from the unsightly confusion of coal pipes characteristic of recent large installations for pulverized coal firing. The boiler front is as neat and free from obstructions as in a conventional oil fired plant, as shown by the photograph, Fig. 3. Draft and combustion are governed by a complete system of automatic control.

The main generating unit, shown in Figure 1, is a 40,000 kw., 80 per cent power factor, 3,600 r.p.m. General Electric machine, with an 1,800 r.p.m., 140 kw. exciter, driven from the main generator shaft through a reduction gear. The tandem compound turbine has 25 rows of impulse blading. The high pressure element has one Curtis stage with two rows of blades, and 17 Rateau stages each with a single row of blades. Steam is extracted at the 8th, 12th and 18th stages, the latter being the cross-over pressure between the high and low pressure casings. The three stage low pressure element is double flow and therefore has six rows of blades, those in the 21st stage having an effective length of 16.5 inches. The 50,000 kv-a., 11,500-v. generator is air-cooled, and three motor driven fans circulate the cooling air through the generator windings and the tubular air coolers in a closed system. A permanently connected turning gear maintains a speed of 2 r.p.m. during standby and warming-up operations.

The design operating conditions are:

	Normal	Maximum
Steam pressure at throttle	850 lb. gage	900 lb. gage
Steam temperature at throttle	900 deg. F.	950 deg. F.
Absolute back pressure	1.5 in. Hg.	2.5 in. Hg.

The turbine is designed to produce 45,000 kw. net at the generator terminals at 90 per cent power factor under the above normal conditions, and also with a throttle steam temperature of 835 deg. F. and with a back pressure of 2.5 in. Hg. The low pressure element of the turbine has a welded steel plate exhaust nozzle which is field welded to the steel plate shell of the 36,000 sq. ft. double pass condenser. Circulating water is supplied by two 18,000 g.p.m. vertical pumps located in the screen house on the river front. The cross section, Fig. 2, shows the supply and return lines which are enameled steel pipes run below ground and under the boiler into the turbine room basement. The plates are enameled by a hot process inside and out, and the underground sections are wrapped. Circulating water is chlorinated automatically at the intake.

The feed heating cycle for the extension is shown in the Heat Balance Diagram, Fig. 4. The heat balance, like the major equipment, was designed primarily for reliability, operating simplicity and low generating costs, including capital charges as well as production expense. In many plants operating at comparable pressure, four or five stages of extraction are used. While additional feed heating stages would have increased the thermal efficiency, and while a reasonably high efficiency is essential to low production expense with New England fuel prices, each stage of extraction adds to the capital cost and operating complexity. To conform with the principles of design above stated, it was decided to limit the number of extractions to three, but to make highly effective use of each stage in the feed heating cycle.

As shown by the diagram, condensate is delivered by the condenser hot well pump to an open heater at the 18th stage. It is then delivered by a booster pump through a closed heater at the 12th stage to a second open heater at the 8th stage. From the latter,

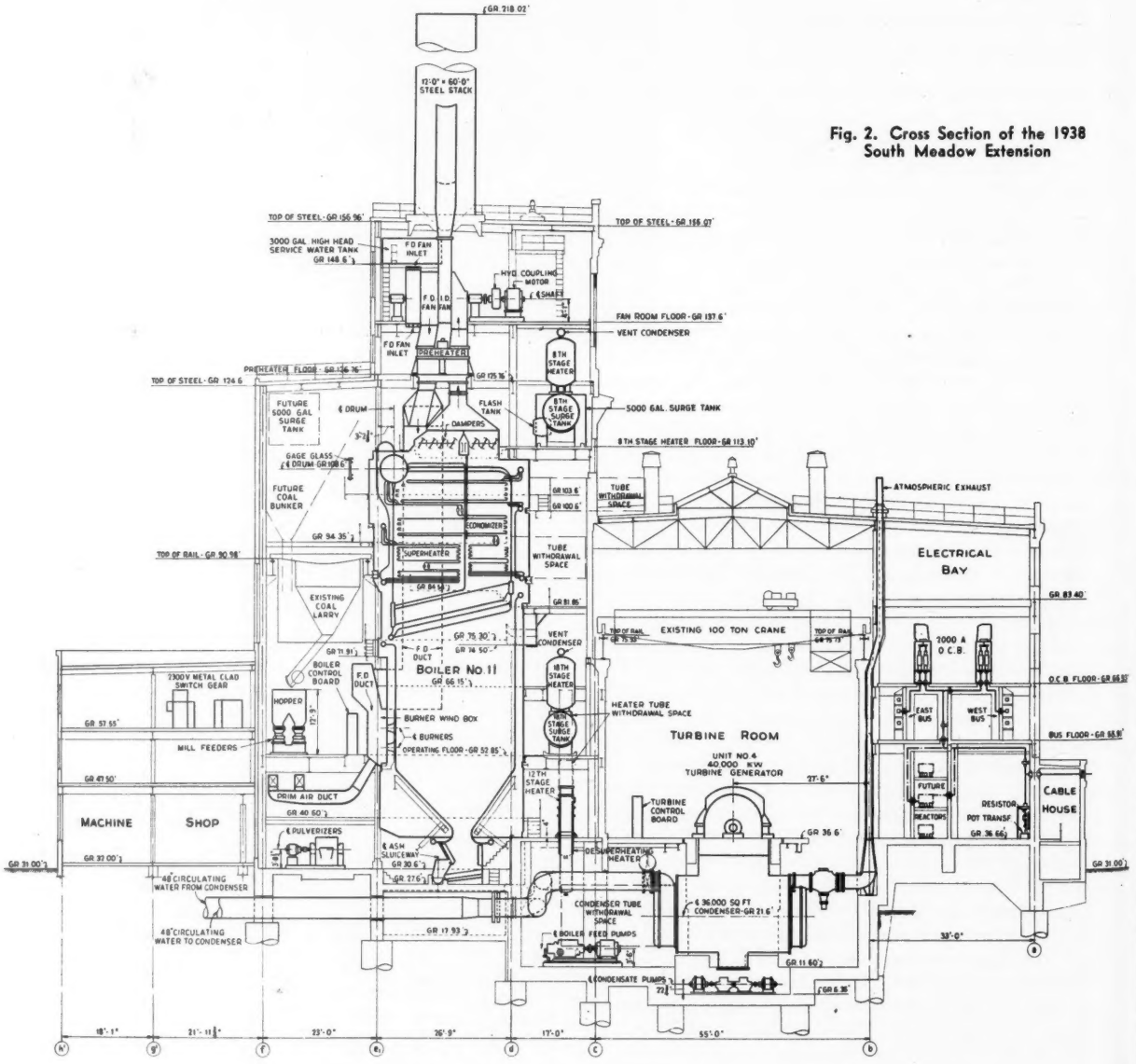


Fig. 2. Cross Section of the 1938 South Meadow Extension

the main boiler feed pump delivers the water to the economizer of the steam generating unit through a closed heater, where it is heated 7 F. above the saturation temperature of the extracted steam. There are duplicate motor driven hot well pumps, condensate booster pumps and boiler feed pumps. In addition there is a steam driven boiler feed pump, designed for quick starting. This pump is purely for emergency service, and the turbine, which takes steam at full boiler pressure and temperature, exhausts directly to the atmosphere.

Evaporator equipment previously installed provides the makeup water required for the 1938 extension. Surge tanks beneath the 18th stage and 8th stage heaters provide a liberal storage volume of hot condensate in the system. For storage of cold condensate, a 40,000 gal. tank was built into the boiler foundation. The steam driven boiler feed pump, which is started automatically by loss of differential pressure across the feedwater controls, has a suction connection from this tank, but this is for use only in an extreme emergency. Distilled water pumps, started automatically by low level in either of the hot surge tanks, deliver water from the distilled water tank to the 8th stage heaters or the surge tank which feeds the 18th stage heater, and insure a supply of hot deaerated water to the feed pumps at all times.

Open heaters, by heating the condensate to the full saturation temperature of the steam, extract more steam from the turbine than would be possible with closed heaters, where some terminal difference between the temperature of the steam and water is unavoidable. The open heater at the 18th stage extracts approximately 4 per cent more steam than would be possible with a closed heater of reasonable cost and dimensions. This is particularly desirable at the lowest pressure extraction, where the steam has converted more of its energy into power than at the higher pressure stages. The higher quantity of steam extracted by open heaters has a compound effect; it reduces the flow to the condenser, where the latest heat is lost to the circulating water, and it reduces the flow and velocity through the lowest pressure wheels of the turbine, resulting in a higher efficiency in the final stages. In this particular turbine the area through the 21st stage buckets is not liberal, and the additional steam extracted by the use of open, rather than closed heaters, effects an appreciable increase in the efficiency of the unit.

The above considerations would apply, though with less force, to the 12th stage heater. In this case, however, a closed heater was used to avoid the cost and complication of a second booster pump. The efficiency sacrificed is relatively small. A drip pump is provided to avoid the degradation of energy which would result from following the not uncommon practice of cascading the drips into the lowest pressure heater. Trapping the drips from the 12th to the 18th stage heater and allowing them to flash in the latter would reduce the amount of steam which could be extracted from the 18th stage by nearly 10 per cent.

The combination of an open and closed heater at the 8th stage gives the maximum possible steam extraction at that point, where the bled steam is

Fig. 3. The boiler front

highly superheated, and results in the highest possible final feed water temperature entering the steam generating unit. Another advantage of the open heater at the 8th stage is its effect on feed pump performance. The pressure in this heater increases with the load on the main turbine, giving a rising suction pressure with increasing rates of output. Due to the increased friction in piping, controls and economizer, the feed pump discharge pressure also rises with increasing load, but the suction pressure rises more rapidly than the discharge pressure, and the total dynamic head on the pump decreases as rate of delivery goes up. The result is that the system characteristic approximates the constant speed characteristic of the pump and, although the pumps are driven by constant speed induction motors, very little power is wasted by throttling at boiler feedwater level controls, even at light loads. The advantage of the constant speed motors for this large and important drive is obvious, both with respect to cost and to operating simplicity.

The installation of two open heaters in series, the first venting to the condenser where noncondensible vapors are removed by the vacuum pump, and the second venting to the atmosphere, provides highly effective deaeration. The provision of a heating coil in the 8th stage storage tank prevents the introduction of highly aerated water into the boiler during refilling operations.

The effective use of extracted steam and the careful avoidance of degradation of energy result in less than 75 per cent of the throttle flow reaching the condenser, in spite of the fact that only three stages of extraction are used. Under the above stated nor-

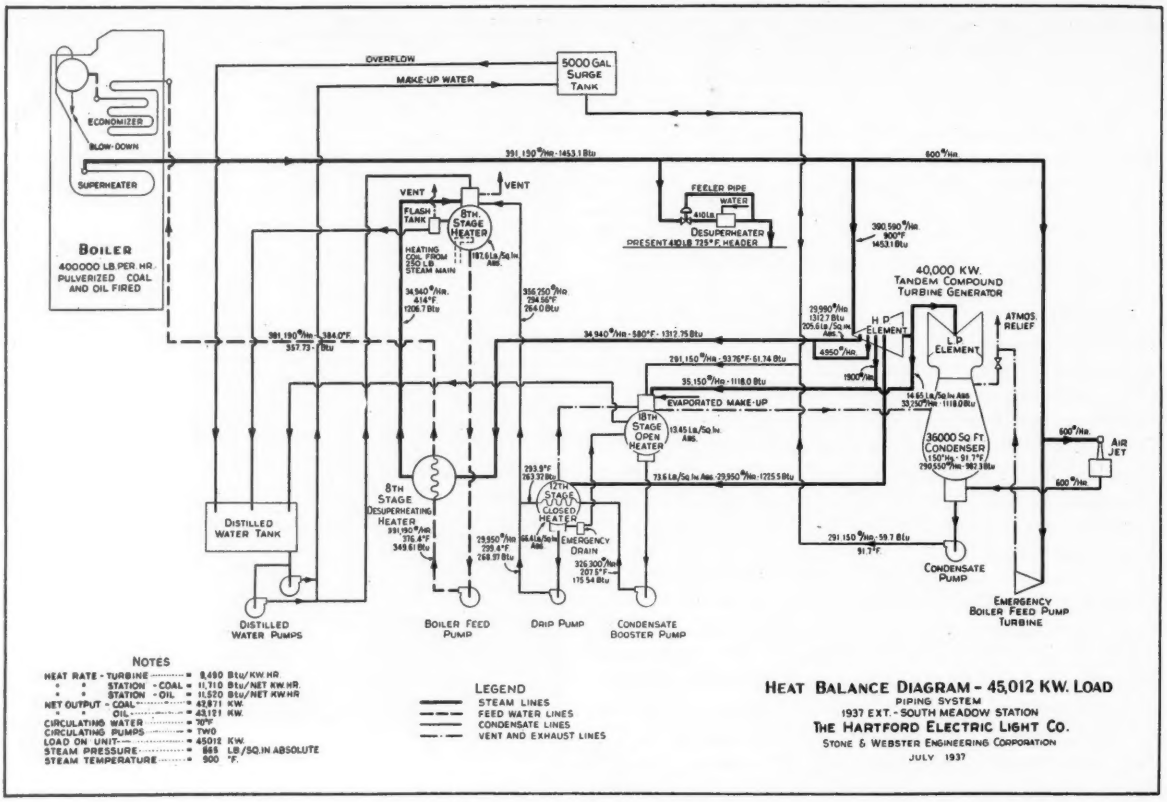


Fig. 4. Heat balance diagram

mal operating conditions, the heat consumption of the turbine at 40,000 kw. net output is approximately 9500 B.t.u. per kw-hr., and the heat consumption of the station at the same output is between 11,300 and 11,800 B.t.u. per kw-hr., depending upon which fuel is used and the temperature of river water supplied to the condenser.

The 900 deg. F. steam lines are carbon molybdenum steel. All joints except at the turbine throttle and the nonreturn valve are welded, and the piping was designed to require a minimum number of field welds. The latter were preheated, annealed, and inspected by X-ray. The high pressure boiler feed lines were also erected with welded joints.

The station is located on the bank of the Connecticut River, and the site presented some foundation problems. Bedrock is approximately 110 ft. below the ground surface. Above the bedrock is a stratum of hardpan about 10 ft. thick, then a bed of soft clay about 55 ft. thick, then a layer of coarse sand 15 ft. thick, covered by a stratum of silt 10 ft. thick and a cinder fill varying from 10 ft. to 30 ft. in depth. The original station was carried on a concrete mat on concrete piles extending into the sand stratum above the clay bed, and while a few inches of settlement have taken place, this has been fairly uniform and no inconvenience or damage to the structure has occurred.

When the mercury unit was installed, the matter of foundation design was reconsidered. The structure to house this equipment occupied a relatively small floor area but the building was high, and the intensity of loading per unit of area and was much greater than for the original structure. Pneumatic caissons were sunk to bed-rock for this extension.

Similarly, the steam generating unit installed in 1930 was much higher than the original boilers, and the consequent intensity of loading on the subsoil was such that pneumatic caissons were sunk to rock to carry the load to the building and equipment. For the 1938 extension, even larger equipment had been developed, occupying a relatively small area for the capacity involved and giving larger loads on smaller areas. For this work, caissons were sunk to rock by a recently developed open method, suitable for the conditions at this site, without the use of compressed air. The work was done in less time and at lower cost than required for the pneumatic caissons previously used. By this method a cylindrical area was drilled by a rotating bit down to hardpan, the hole being kept filled with liquid mud to prevent caving of the earth walls. When the hardpan was reached, the bit was withdrawn and a steel cylinder with a cutting edge was inserted, which was rotated to cut through the hardpan and dig into the bedrock. The hole was then pumped dry, the rock inspected, and the hole filled with concrete. The caissons varied from 5 ft. 0 in. to 6 ft. 6 in. in diameter.

As shown in the cross section, Fig. 2, there are four floors in the electrical bay. The lower floor contains the feeder reactors; on the second floor are located the two main buses; on the third floor are the oil circuit breakers, which are General Electric type FH?6; and on the top floor are the control room and offices. The

Principal Equipment in South Meadow Station

GENERAL

COMPANY: The Hartford Electric Light Company, T. H. Soren, Vice President in Charge of Engineering.

LOCATION: Hartford, Connecticut.

SERVICE: Electric Light and Power.

ENGINEERS AND CONSTRUCTORS: Stone & Webster Engineering Corporation.

STEAM GENERATING EQUIPMENT AND AUXILIARIES

BOILER AND FURNACE: Babcock & Wilcox Company—One sectional header, cross drum, high head type; boiler heating surface 5,240 sq. ft., drum diam. 66 in., water walls 4,494 sq. ft. Constructed for 950 lb. per sq. in. W.S.P.; capacity 400,000 lb. per hr. continuous evaporation.

SUPERHEATER: Babcock & Wilcox continuous tube convection type; 9,230 sq. ft. effective heating surface, designed for 915 F. final steam temperature, and 875 lb. per sq. in. gage pressure at maximum steam output of 425,000 lb. per hr. Temperature automatically controlled by operating dampers.

ECONOMIZER: Babcock & Wilcox Company continuous steel tube type; 23,480 sq. ft. effective heating surface, designed for a maximum W.S.P. of 1,000 lb. per sq. in. gage and to raise feedwater temperature from 350 F. to a final temperature equal to the temperature of saturated steam with a flow of 450,000 lb. per hr.

SOOT BLOWER: Diamond Power Specialty Corporation—Boiler, superheater and economizer equipped with complete soot blowing units.

AIR PREHEATERS: The Air Preheater Corporation—Two Ljungstrom regenerative type; 11,100 sq. ft. effective heating surface each, designed to raise air temperature from an inlet temperature of 80 F. to 436 F. final outlet temperature when boiler is operating at full output and burning pulverized coal.

PULVERIZERS: Riley Stoker Corporation—Four Riley Atrita unit pulverizers with recirculators, coal feeders and magnetic separators. Each mill designed for a maximum output capacity of 12,500 lb. per hr. when using low volatile coal, based on coal to pass a 1¼ in. screen, with preheated air at 350 F. Pulverizers driven by General Electric, 100 hp., 1,150 r.p.m. induction motors..

FUEL BURNERS: Peabody Engineering Corporation—Eight type H-23, Toronto combined pulverized coal and oil burners; designed for burning pulverized coal at a combined maximum rate of 38,900 lb. per hr. with primary air supplied at a rate of 2,400 c.f.m. per burner at 150 F. at a pressure of 3 in. to 3½ in. of water; also to burn bunker C fuel oil at a combined maximum rate of 31,700 lb. per hr. Required secondary air supplied at 430 F. at a wind box pressure of 5 in.

FORCED AND INDUCED DRAFT FAN EQUIPMENT: American Blower Corporation—Two duplex Sirocco forced and induced draft fan units driven through 42 in. American Blower Corporation hydraulic couplings by General Electric Company, 700 hp. 720 r.p.m. induction motors. Forced draft fan, single width, single inlet, with dampers designed to discharge 75,000 c.f.m. air at 12 in. water pressure. Induced draft fan, single width, single inlet, with inlet boxes and dampers designed to discharge 137,000 c.f.m. flue gas at 450 F. at 12.5 in. negative water pressure at fan inlet.

COMBUSTION CONTROL: Leeds & Northrup Company—Pneumatic and electric operation for maintaining uniform steam pressure through adjustment of combustion rate in response to load demand, proportioning supplies of fuel and air to maintain uniform combustion efficiency.

STEEL PLATE WORK: The Whitlock Coil Pipe Company—Steel plate induced draft ducts, boiler to stack, forced draft ducts, fans to wind box, burner wind box, hot air ducts and coal spouts to pulverizers, recirculating and ventilating ducts and pulverizer coal hoppers.

STEEL STACK: Connery Construction Company—Self-supporting steel stack, 12 ft. 0 in. diam. inside lining, 60 ft. 0 in. high, with base 126 ft. 0 in. above yard grade.

ASH HOPPER AND ASH SLUICING: The Allen-Sherman-Hoff Company—Cast iron ash hopper complete with lining, doors, quenchers, sluice and transport nozzles and centrifugal ash removal pump with 50 hp. General Electric 875 r.p.m. induction, dust and moisture-proof motor.

FEEDWATER SYSTEM

BOILER FEED PUMPS: Ingersoll-Rand Company—Three 5 in., seven-stage, 1,800 r.p.m., single suction, centrifugal pumps, two direct connected to General Electric, 1,000 hp. induction motors, and one direct connected to a Terry steam turbine operating at a throttle pressure of 850 lb. gage and temperature of 900 F., exhausting at atmospheric pressure. Total dynamic head 2,610 ft. when boiler is operating at full output.

CONDENSATE BOOSTER PUMPS: Ingersoll-Rand Company—Two four-stage, 1,800 r.p.m., single suction, centrifugal pumps, direct connected to 250 hp. wound rotor, variable speed motors. Total dynamic head 710 ft. at maximum load.

FEEDWATER REGULATORS AND EXCESS PRESSURE CONTROL VALVES: The Swartwout Company — Constant differential pressure, thermal-hydraulic generator type regulators.

EXTRACTION HEATERS: Foster Wheeler Corporation—One vertical 8th stage desuperheating extraction heater, one vertical 12th stage closed extraction heater, one 8th stage direct contact type open heater with 5,200 gal. storage tank and one 18th stage direct contact type open heater with 2,400 gal. storage tank.

CHEMICAL FEED EQUIPMENT: Hills-McCanna Company—Three single feed proportioning pumps driven by General Electric, ¼ hp., 1,725 r.p.m., drip-proof motors through enclosed reduction gearing.

Tippett & Wood—One 100 gal. phosphate feed tank and one sulphite mixing and feed tank.

TURBINE GENERATOR AND AUXILIARIES

TURBINE GENERATOR: General Electric Company—One 40,000 kw., 3,600 r.p.m. turbine for condensing operation, having an overload capacity sufficient to deliver 45,000 kw. continuously at 90 per cent power factor. Turbine with three openings for extraction of steam. A turning gear is included. One 40,000 kw., 80 per cent power factor, 50,000 kv-a., generator, direct connected to turbine, complete air cooler and fans for generator, also oil coolers for lubrication system. Normal steam pressure at throttle 850 lb. per sq. in. gage and 900 F. temperature. Generator 3 phase, 60 cycle, 11,500 v., 80 per cent power factor wound for excitation at 250 v.

EXCITER: General Electric Company—One 140 kw., 250 v., exciter driven through reduction gear from generator shaft to supply necessary exciting current for the main generator.

STEEL PLATE WORK: The Whitlock Coil Pipe Company—Steel plate generator air ducts, with Johns-Manville Aircoustic sheets and Precemented Silento felt for sound absorption.

GENERATOR FIRE PROTECTION: American LaFrance & Foamite Industries, Inc.—CO_2 fire protection equipment.

SURFACE CONDENSER SYSTEM

SURFACE CONDENSER: Westinghouse Electric & Manufacturing Company—One 36,000 sq. ft. cooling surface, two-pass radial flow type, welded shell construction with nondivided cast iron water boxes. Two 18,000 g.p.m. each, vertical propeller circulating pumps direct connected to 200 hp., 870 r.p.m. Westinghouse motors; two 700 g.p.m. each, horizontal 2-stage condensate pumps direct connected to 60 hp., 1,160 r.p.m. Westinghouse motors and two 2-stage steam jet air ejectors.

CONDENSER TUBES: Bridgeport Brass Company—36,000 sq. ft. ⅞ in. O.D., No. 18 B.W.G. Admiralty mixture tubes.

CIRCULATING WATER VALVES: The Chapman Valve Manufacturing Company—O.S.&Y. gate valves operated by General Electric motors.

CIRCULATING WATER LINES: New York Engineering Company—30 in., 42 in., and 48 in. suction and discharge piping, welded steel plate, enameled by Wailes Dove-Hermiston hot process. Underground sections wrapped with two layers of 15 lb. tar saturated felt.

INTAKE WATER SCREENS: Link-Belt Company—Two 6 ft. 0 in. wide vertical revolving type with 5 hp., 1,750 r.p.m., General Electric splash-proof motors. Speed reducers, complete with refuse trough and spray piping.

SLUICE GATES AT INTAKE WELL: The Chapman Valve Manufacturing Company—Two 48 in. x 72 in. cast iron gates with hand-operated floor stands.

TRASH RACK: The Porcupine Company—Two sets of racks and guide castings.

SCREEN WASH AND UNWATERING PUMP: Worthington Pump and Machinery Corp.—4-stage deep well pump with 25 hp., General Electric motor.

CIRCULATING WATER CHLORINATING EQUIPMENT: Wallace & Tiernan Products, Inc.—Chlorinators and accessories to inject chlorine gas into condenser circulating water tunnels.

ELECTRICAL EQUIPMENT

TRANSFORMERS: General Electric Company—Five single phase, 60 cycle, 1,000 kv-a. transformers for 2,300 v. station service supply.

REACTORS: General Electric Company—Six single phase, 93.5 kv-a. feeder reactors for 11,000 v. outgoing circuits.

SWITCH GEAR: General Electric Company—Station service 2,300 v. metal-clad and truck type panels. Main control panels for generator, exciter, feeders and station service. Type FH-26 oil circuit breakers for generator and feeder circuits.

INSTRUMENTS

BOILER METER, WATER LEVEL RECORDER AND DRAFT GAGES: Bailey Meter Co.

STEAM AND WATER FLOW METERS: Bailey Meter Co.

RECORDING THERMOMETERS: Leeds & Northrup Co.; The Bristol Co.

INDICATING THERMOMETERS: Taylor Instrument Co.

TEMPERATURE RECORDER CONTROLLERS: C. J. Tagliabue Mfg. Co.

INDICATING PRESSURE GAGES: Crosby Steam Gage & Valve Co.; Consolidated Ashcroft Hancock Co., Inc.

BAROMETER AND VACUUM RECORDER: Uehling Instrument Co.

CONDENSER CONDUCTIVITY RECORDER: Leeds & Northrup Co.

OIL METERS: Neptune Meter Co.

GAGE BOARDS: G and N Engineering Co.

MISCELLANEOUS EQUIPMENT

PIPING: Grinnell Co., Inc.

PIPE COVERING: Johns-Manville Sales Corporation.

VALVES

BOILER SAFETY: Consolidated Ashcroft Hancock Co., Inc.

BOILER NONRETURN: Schutte & Koerting Co.

BOILER FEED STOP AND CHECK: The Edward Valve & Mfg. Co.

BOILER BLOW-OFF: Yarnell-Waring Co.

HIGH PRESSURE STEAM AND WATER GATES: The Chapman Valve Manufacturing Co.

HIGH PRESSURE GLOBES AND CHECKS: Manning, Maxwell & Moore, Inc.; The Lunkenheimer Co.

LOW PRESSURE GATES AND GLOBES: Reading-Pratt & Cady Co., Inc.

CONTROLS AT EXTRACTION HEATERS: The Swartwout Co.

PRESSURE REDUCING AND DESUPERHEATING EQUIPMENT: Republic Flow Meters Co.

ATMOSPHERIC RELIEF: Atwood & Morrill Co.

CONTINUOUS BLOWDOWN: The Ludlow Valve Manufacturing Co.

RELIEF: Crosby Steam Gage & Valve Co.

HEAT EXCHANGER: The Whitlock Coil Pipe Co.

BLOWDOWN SAMPLE COOLER: Cochrane Steam Specialty Co.

DISTILLED WATER PUMPS, HEATER DRIP PUMP, AND SUMP PUMPS: Ingersoll-Rand Co.

FUEL OIL HEATERS: The Griscom-Russell Co.; The Whitlock Coil Pipe Co.

FUEL OIL PUMP: Quimby Pumps Agency.

FUEL OIL SERVICE TANK: Chicago Bridge & Iron Co.

LUBRICATING OIL PURIFICATION EQUIPMENT: S. F. Bowser & Co., Inc.

COOLING WATER PUMPS, ASH SLUICING PUMP, SERVICE WATER BOOSTER PUMPS AND SUMP PUMPS: Worthington Pump and Machinery Corp.

VACUUM CLEANING EQUIPMENT: Spencer Company of Boston.

MISCELLANEOUS TANKS AND PLATEWORK: The Whitlock Coil Pipe Co.

Fig. 5. The fan room

The fans are combination units, one forced draft and one induced draft fan mounted on a single shaft. Each pair of fans is driven by a constant speed motor through hydraulic coupling which permits smooth and accurate speed regulation for 20 to 98 per cent of the full load motor speed which is 705 r.p.m.

main 11,000 v. buses, which consist of copper channels, are mounted in masonry compartments and are separated by a center fire wall. Selector oil circuit breakers are provided on all generator and feeder circuits.

While the new equipment has been in operation only a few weeks, the results to date are gratifying and indicate that the designers' expectations will be realized with respect to efficiency, reliability and operating cost.

The advance in the art of power generation is illustrated by a comparison of the 1938 extension with the original installation at South Meadow. Both have the same rated capacity, but the 1938 extension operates at approximately 65 per cent of the fuel consumption, was installed at 75 per cent of the cost, and occupies 50 per cent of the ground area and building volume of the original plant. The comparison of cost, ground area and building volume are made after all allowances for differences in the scope of the work included in the respective jobs.

Large Turbogenerator Standards

Utilities, manufacturers and Federal government collaborate in preparation of standards to expedite construction of generating stations and lower engineering costs

PREFERRED STANDARDS for steam turbine generators of 10,000 kw. rating and above were recently approved by the National Defense Power Committee with a view to expediting the production and reducing the costs of such equipment and accelerating the construction and erection of generating stations to provide additional supplies of electric energy. The Committee is considering similar determinations for generators of smaller ratings.

In the past turbines and generators of large capacities have been chiefly "tailor-made jobs" built to order on special designs prepared by the utility engineers. This has meant the expenditure of a large amount of time on engineering and design for each machine and has in large part prevented the adoption of quantity methods of production.

These preferred standards provide sufficient latitude for the modification of the standards to meet the special conditions arising in connection with the installation of new equipment in existing plants or where unusual physical conditions must be met. Provision is also made for the consideration of technical advances in the art.

These provisions are emphasized in the technical report prepared for the Subcommittee on Standardization by John C. Parker, President of the American Institute of Electrical Engineers and Vice President of the Consolidated Edison Co., representing the utilities; C. S. Coggeshall, Sales Manager, Turbine Department of the General Electric Co., representing the electrical equipment manufacturers; and Thomas R. Tate, representing the National Defense Power Committee. Twenty-two representatives of the manufacturers, utilities and the Government cooperated in recommending the adoption by manufacturers and industry of the standards

which the Subcommittee has unanimously agreed upon. Portions of the Subcommittee report follow:

The immediate objective of the establishment of preferred standards for turbine generators is the maximum speed of provision of power facilities to anticipate peace-time requirements and to facilitate wartime provision of power through elimination of any unnecessary special designs or sizes. It is expected, incidentally, that the cost of power plant installations will be sufficiently reduced to compensate for any added economy or other advantages that might result from more special designs.

Related Equipment

It is the belief of the Subcommittee that the advantages of preferred standards as here recommended for turbine generators will be reflected also in such associated equipment as boilers and appurtenances, steam piping, valves and fittings.

While the advantages of unified practice with reference to associated equipment, such as condensers, piping, pumps and boilers are of great significance, the Subcommittee recognizes that the difficulty of standardization is probably greater than in the case of turbine generators and is not prepared at the present moment to make specific recommendations. It does, however, suggest the desirability of further consideration.

It is the intention that the preferred standards will be followed in the building of all new generating stations and in all installations within existing stations unless interrelation with existing equipment clearly calls for special designs. Deviation from these proposed standards if of decided advantage to the public, or if necessitated by physical conditions, or by the fundamental purpose of rapid creation of power facilities for national defense will be deemed to be consistent with this program. In all such cases the burden of clear proof rests upon any one proposing such deviation.

Illustrative of such cases in which deviation will be deemed to be in the spirit of this program but not intended to be all inclusive, are: Temperature of condensing water supply may require turbines designed for operation wth back pressures higher than provided; the present availability in manufacturers' plants of turbine generators well advanced in production points clearly to the completion and use of such equipment; duplication of a turbine generator, not currently discontinued by the manufacturer as an active design. may expedite manufacture and installation of power facilities; the manufacture and installation of turbine generators adapted to meet essential requirements in existing stations may facilitate rapid creation of generating capacity.

The preferred standards are intended to be progressive standards and, consistently with the fundamental purpose of expediting production and installation of power generating equipment, are intended to permit technical and economic developments. To that end they should, at least annually, and as occasion seems clearly to warrant, be reviewed to determine whether advances in the art call for specific modification.

The accompanying tables show the preferred standards for seventeen sizes of condensing or topping turbine generators from 10,000 to 100,000 kw. rating. The preferred standard generator voltage will be 13,800, but voltages of 11,000, 11,500, 12,000, 13,200 or 14,400 may be furnished and will not be considered special if required to meet the needs of any existing distribution system.

Superposed Turbines

Three extraction openings shall be provided for condensing machines of 10,000 to 25,000 kw. rating, and four for all machines of 35,000 kw. and higher ratings. The temperature at extraction openings, subject to a tolerance of plus or minus 10 deg. F., will, at rated output, be 170, 225 and 290 deg. F., with an extraction temperature of 350 deg. F. for the fourth opening specified above for machines of 35,000 kw. and higher ratings. The turbine capacity shall be such as to deliver the full kv-a. rating of the generator at unity power factor.

The recommended speed of all superposed turbine generators in the table is 3600 r.p.m.; the throttle pressure 1250 lb. per sq. in. ga.; throttle temperature 925 deg. F. and the range of back pressures from 200 to 300 lb. per sq. in. ga.

Preferred standards for steam turbine generators as recommended by the sub-committee on Standardization of the National Defense Power Committee. Participating in the conference were seven representatives of the Federal government, 12 representatives from three manufacturing companies and three representatives of the electrical utilities

CONDENSING TURBINES

GENERAL: All sizes: Back pressure 1" or 1½" Hg. abs.; short circuit ratio 0.9; generator voltage 13,800; excitation voltage 250

Rating, kw.	10,000	12,500	15,000	20,000	25,000	35,000	50,000	75,000	100,000
Speed, r.p.m.	3,600	3,600	3,600	3,600	3,600	3,600	3,600	1,800	1,800
Throttle pressure, lb.per sq.in.ga.	650	650	650	650	650	850 or 1,250	850 or 1,250	850 or 1,250	850 or 1,250
Throttle temperature, deg. F.	825	825	825	900	900	900	900	900	900
No. of extraction openings	3	3	3	3	3	4	4	4	4
Temp.at extrac.openings 10 deg.F.at rated output	170/225/290	170/225/290	170/225/290	170/225/290	170/225/290	170/225/290/350	170/225/290/350	170/225/290/350	170/225/290/350
Turbine capacity, % of kw. rating	125	125	125	125	125	125	125	125	125
Power factor	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Generator cooling	Air	Air	Air	Air	Air or Hyd.	Hyd.	Hyd.	Hyd.	Hyd.

SUPERPOSED TURBINES

GENERAL: All sizes: 3600 r.p.m.; throttle pressure and temperature 1250 lb./sq. in. ga., 925 deg. F.; back pressure 200-300 lb./sq.in. ga.; short circuit ratio 0.9; generator voltage 13,800; Excitation voltage 250.

Rating, kw.	10,000	12,500	15,000	20,000	25,000	35,000	50,000	60,000
Turbine capacity, % of kw.rating	111	111	111	111	111	111	111	111
Power factor	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8 or 0.9
Generator cooling	Air	Air	Air	Air	Air or Hyd.	Hyd.	Hyd.	Hyd.

Modernization Trends In

Part I. Introduction. Aspects of the power requirements of various types of textile plants and methods of classification. A specific consideration of mills with service requirements most favorable for using purchased power.

BY M. K. BRYAN

Chas. T. Main, Inc.,
Boston, Massachusetts

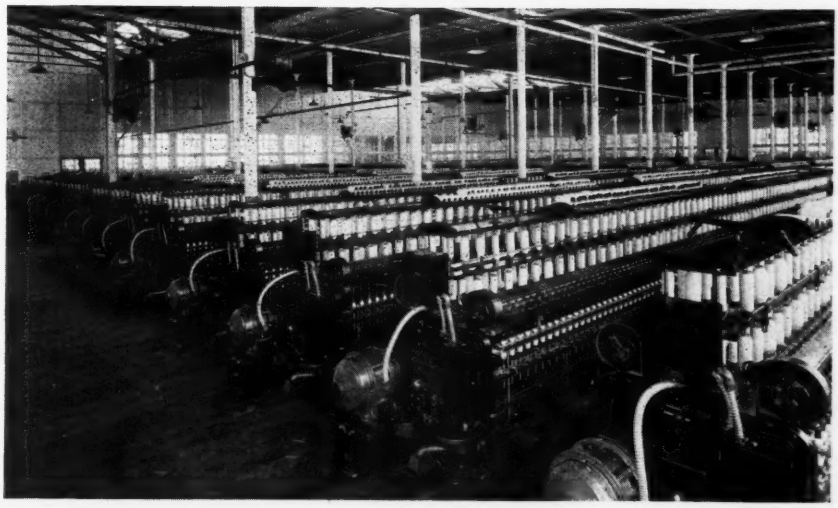
THE TEXTILE INDUSTRY, if not the oldest, is one of the oldest industries in the country and its early origin has a considerable influence today upon the commercial aspect of modernizing its power and steam supplies. This is to be expected when it is remembered that power generation by any means other than with the water wheel was in its infancy long after the textile industry was well established. The generation and transmission of electricity are commercially about 50 yr. old whereas the first cotton mill was built and operated in Rhode Island over 100 yr. ago. The industry accordingly started with water driven mills and many of the original sites are in operation today with the old water power developments still in use, although in most cases they are not adequate in capacity for the full requirements of the mill, and, due to variable stream flow, can not be a continuous power supply. These old water powers do, however, furnish a considerable amount of power and are a definite factor influencing the character of many new developments. Many of these water power developments are a genuine asset, some are of questionable value, and others have only sentimental value. All of them complicate the power and steam supply picture.

The industry welcomed the development of the steam engine. Mill sites were no longer tied to water power sites, and easy expansion of the industry was made possible. Electric power generation was adopted by some mills early in its development and long distance transmission of electricity, a few miles, which was a long way in the early days, was pioneered in some textile properties. The steam turbine was accepted by some of the more forward mills early in its development, one of the first extraction turbines sold by the General Electric Company being installed at the Arlington Mills in Lawrence, Mass., about 1905. Improvements in boilers and steam generating economy were welcomed and adopted by the industry. It appears that the first installation of air preheaters in land practice was made at the Pacific Mills in Lawrence about 1881. Steam pressures were raised to keep step with the best engine and turbine practice. The receivers of compound engines were bled to supply steam for process work. The New England Cotton Manufacturers Association awarded medals in recognition of meritorious papers pertaining to power and steam operations in the plants of the cotton mills.

All of this happened before the World War. During and immediately following the war, the textile industry

DURING the past year there appeared in these pages a series of articles dealing with the current building programs of various public utility systems. The purpose of this series was to show the trend of development in modernizing power plants and power systems. The utility industry, however, represents only a portion of the power plant industry since it does not include the thousands of private plants furnishing power to industry. To complete the picture, therefore, there will be presented another series, considering modernization practices in industrial power plants. Insofar as possible the industrial power plants will be considered with respect to the industries they serve but where this method of classification is not feasible, they may be considered with respect to their service requirements. The series begins with this splendid discussion of textile power plants by Mr. Bryan of Chas. T. Main, Inc. The author and the firm he is associated with have for many years been intimately concerned with textile mill power development and he is therefore eminently qualified to discuss this subject. Mr. Bryan's article will be presented in three parts, this being the first; the other two will appear in subsequent issues.

Textile Mill Power Plants



The Textile Industry, if not the oldest, is one of the oldest industries in the country. This is a view in a modern motor driven mill.

expanded its productive capacity to a point which has since been contended as being detrimental to the industry, for since the early 1920's the mills of the industry, by and large, have not been financially successful. Mill management, accordingly, has been reticent and unwilling to make capital expenditures excepting under compulsion. So therefore, during the past decade of rapid and marked development in power and steam generating economy, the textiles, it appears, have done an about-face on the power plant policy, for as a whole they have not taken advantage of the general power and steam situation to the same extent as other industries, such as chemicals, oils, and paper. In many cases, improvements by which operating costs can be reduced are delayed until bad physical condition of equipment forces its retirement. Power and steam costs are conventionally regarded as of slight importance, although in many mills the cost of power and steam is equal to or greater than the fair profit on a good average year's business.

If judged by the present situation in most mills, the industry does not appear to be power or steam conscious as it was during the period of its development.

Lest this statement be considered as a flat condemnation of the industry's attitude toward its power and steam problems, let it be said that the few new mills built in recent years and the more successful existing properties have appraised the power and steam situation and taken whatever appeared to be full commercial advantage of its possibilities.

The steam and power service requirements in their relation to each other vary widely in different types of textile plants and in different mills of the same type. The textile industry in its variety of products, locations and requirements, includes mills having steam and power demands justifying the full range of power supply possibilities, from 100 per cent purchased power to 100 per cent generated power. Each plant, therefore, is distinctly an individual situation.

Since it is not possible to catalogue development trends, this article will not give much detail of any particular plants. Rather, the attempt will be to point out the broad possibilities for general divisions of the industry and illustrate some of these by reference to specific mills, typical of their kind and classification.

The mills of the textile industry can be classified for power plant consideration, into three general groups, to wit:—

(1) mills where the steam requirements are largely for space heating and, consequently, where there is a high ratio of power consumption, to steam consumption,—plants with conditions least favorable to steam power generation;
(2) mills where the steam requirements for process work are enough so that the ratio of power consumption to steam consumption may be favorable for some steam power generation; and
(3) mills using considerable process steam, a condition most favorable for steam power generation and for high economy in steam generation.

In general the various mills of the industry will classify under the above grouping as in the accompanying table (Table I).

The designations, in the table, are broad and no attempt was made to list all varieties of mills. The intent was to use designations so that one familiar with the industry might classify a particular mill through the similarity of its processes to those of some designated unit.

Each of these three groups will be considered in detail. Group 1 will be considered in this installment, while groups 2 and 3 will form the subject of two subsequent articles.

TABLE I. GENERAL TEXTILE MILL CLASSIFICATION BY RELATION OF POWER TO STEAM REQUIREMENTS

GROUP 1 — Ratio Power to Steam Consumption is Least Favorable for Steam Power Generation	Size of Mills		GROUP 2 — Ratio Power to Steam Consumption May Favor Some Steam Power Generation	Size of Mills		GROUP 3 — Ratio Power to Steam Consumption is Most Favorable for Steam Power Generation	Size of Mills	
	Range Kw.	Mean Kw.		Range Kw.	Mean Kw.		Range Kw.	Mean Kw.
COTTON			**COTTON**			**COTTON**		
Grey Yarn Mills	200–3000	1000	Colored Goods Mills	500–4000	1500	Bleachery	1000–3000	1500
Grey Goods Mills	500–4000	1500				Dye & Print Works		
						Finishing Plants		
WOOL			**WOOL**			**WOOL**		
Yarn Mills	400–1500	1000	Top Mills	300–800	500	Complete Woolen Mills	300–1200	500
Weaving Mills	100–1000	400	Weaving & Finishing Mills	250–2500	500	Complete Worsted Mills	2,500–12,000	8000
SILK & RAYON			**SILK & RAYON**			Wool Scouring Plants	75–200	100
Throwing Mills	200–500	300	None	.....	....	**SILK & RAYON**		
Weaving Mills	300–1500	750				Dye & Print Works	1000–2000	1500
Complete Mills	2000–3000	2500						
Spun Rayon Mills	.....	....						
JUTE & SISAL			**JUTE & SISAL**			**JUTE & SISAL**		
Complete Mills	750–5000	3000	None	.....	....	None	.....	....
Special Process Mills	50–300	100						
FLAX			**FLAX**			**FLAX**		
Yarn & Thread Mills	200–500	300	None	.....	....	Bleachery	300–750	500
Complete Mills	.....	1500						
Special Process Mills	50–300	100						

GROUP 1—MILLS WITH SERVICE REQUIREMENTS MOST FAVORABLE FOR PURCHASED POWER

These are the mills using practically no steam excepting for space heating. These mills usually, though not always, buy electricity from the utility, using such power as can be made by the mill's water power development if there is one.

The steam demands in these mills for process purposes are generally small, being in the order of about 3 to 4 lb. of steam per kw-hr. of power consumption. The space heating demands occur largely at times when the mill machinery is not operating and when needs for power are practically nil. As a consequence, not much steam power can be made non-condensing as a by-product of mill steam needs and steam power generation in these mills must compete with utility power largely on a straight condensing basis. Where utility rate structures are reasonable, steam power generation is not likely to be commercially economic.

There are, however, mills in this classification

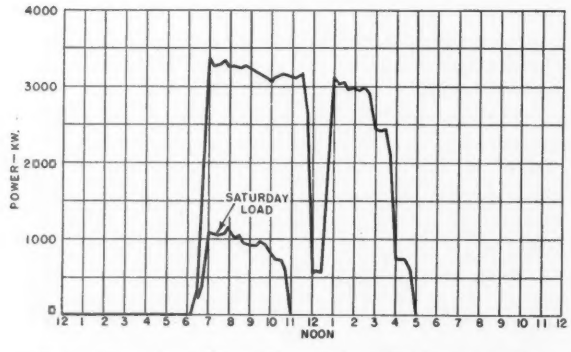


Fig. 1. Power Load Curve. Typical shape for Group 1 Mills

generating their power, some with steam and others with Diesel engines. These plants are at present in the minority and it is believed that private generation is used because local utility power rates are objectionable. A mill built recently generates all power with Diesels rather than purchase electricity. This company, having an excellent financial condition and operating two other properties, all power being purchased for one and generated for the other by its hydro-electric plants, chose to use its capital for power generation rather than hire the utility's capital and be obligated for a "Demand Charge" in bad business periods.

This mill, located on the Atlantic seaboard in a highly developed industrial district, could either contract for its power for a ten-year term at a price to average between ten and eleven mills, or build its generating plant. The proposed power contract included a "Demand Charge" of about $16.50 a kilowatt a year, the equivalent of 12½ per cent fixed charges on an investment of $134.00 a kilowatt; or, if interest is figured at 4 per cent instead of 6 per cent, it is then the equivalent of fixed charges on $160.00 a kilowatt first cost of plant.

The owners elected to generate rather than purchase and a Diesel engine station was built. This mill when in full operation has a demand of about 1800 kw., operates 80 hr. a week, and consumes about 6,000,000 kw-hr. annually. Processes require about 2500 lb. of steam an hr. at 60 lb. pressure. Space heating is practically nil during working hours.

The station which was built for these services consisted of three 700 kw., 225 r.p.m., 60 cycle, 600 v., Diesel engine generator sets, and one 110 kw. Diesel engine generator set for early morning and week-end operation, installed in a new building with the steam generating equipment. This equipment consisted of

waste heat boilers on the large engines and two internal furnace oil-fired boilers. The engines, boilers, switchboard and all auxiliaries, including air compressors for factory air supply, were housed in one building which is about 74 ft. sq. and 22 ft. high floor to roof. Oil tanks are buried outside the building. About 900 sq. ft. of the floor area is allocated to steam boilers and mill compressors, and 4600 sq. ft. to engines, Diesel auxiliaries and switchboard. This is roughly 2.1 sq. ft. of area per kilowatt of installed capacity. The cost of this plant in 1936 complete, building included, was roughly $120.00 per kilowatt of installed capacity, or $146.00 per kilowatt of demand.

The cost to operate this plant, producing about 2,500,000 kw-hr. annually, has been 8 mills per kw-hr., which includes labor for attendance of steam boilers. Conservative adjustment of recorded expenses to a basis of 6,000,000 kw-hr., gives a power cost of 6 mills per kw-hr.

The demand charge in the rate structure of the utility in this instance was somewhat higher than is generally encountered.

Another mill in this group having the problem of purchase vs. private plant power supply, recently chose to purchase rather than generate. This mill, located in central New York state, needed to replace its old boilers. The advisability of extending this operation to include steam power generation, compared to a simple boiler replacement with purchased power, was investigated. The mill consumed just under 6 million kw-hr. annually with a demand of 3000 kw. The steam load for process purposes was approximately 10,000 lb. an hr. and this, combined with extreme heating peaks, called for a steam supply of about 25,000 lb. per hr. The possibilities here can be summarized as follows:

(a) Complete plant for generating power and steam cost per kw. of demand....$136.00
(b) Simple boiler replacement, equated to cost per kw. of demand..... 12.00
(c) Investment increment chargeable for generation per kw. of demand..... 124.00
(d) Annual saving in operating expense by generating instead of purchasing power if capitalized at 10 per cent amounted, per kw. of demand, to..... 120.00

The margin favorable to purchased power was accordingly small. Purchased power was chosen in preference to private generation and the small margin of its advantage was recognized in selecting the equipment with which the old boilers were replaced. The new boiler installation was made with stoker-fired water-tube units. These were designed for 450 lb. working pressure, to accommodate superheaters, and be suitable for economic steam supply to turbo-generators if the purchased power situation changes to justify power generation.

This installation, although costing twice as much as the simplest boiler replacement, established the fundamentals for economic steam power generation and saved enough from the cost of coal to carry the fixed charges on the additional investment.

The general shape of load curves for plants in this group is similar. Load factors vary considerably, ranging from about 20 to 40 per cent with working hours ranging from 40 to 80 per week. Figure 1 illustrates the load curve of a mill with 21 per cent load factor.

NOTE: This is the first of a series of three articles on Power Practices in the Textile Industry by Mr. Bryan. The second, devoted to a consideration of the second group of textile mills, will appear in the March issue.

Grand River Dam

By H. D. ROBARDS

CONSTRUCTION of the first cofferdam has just been finished for the big power-flood control project in Northeast Oklahoma which will be known as the Grand River Dam. It is being built by the Grand River Dam Authority, an organization of some 16 Northeast Oklahoma counties, with PWA aid at an estimated cost of approximately $22,000,000. Ray McNaughton, Miami, and Owen Butler, Grove, are president and secretary respectively of the authority; R. L. V. Wright is general manager.

Physically the dam project is interesting because it is the culmination of a dream of forty years held by one resident of the area, who has been working for it just that long. It will back water up in the corners of Missouri and Arkansas which abut Oklahoma and will also be noticed, but slightly, in Southeast Kansas.

The dam itself will be the longest multiple arch dam in the world, 6,100 ft., 152 ft. high, with an 800-ft. spillway and a second 920-ft. separate spillway a mile east of the dam proper, and the lake formed will have a shore line of 1,100 mi. while the volume of water impounded will be sixth in the United States. Material requirements figure at 450,000 cu. yd. of concrete and 75,000 tons of steel. Excavation estimates include a million cubic yards of dirt and 100,000 cu. yd. of rock. The powerhouse will be 300 ft. long, providing space for two extra turbine-generator units. Five Allis-Chalmers turbines connected to 5 Westinghouse generators have been contracted for to supply from 60,000 to 65,000 kw. daily. The dam will tie to a 157-ft. limestone bluff on the west side, with the power units being located in that end.

Normal water level will be the 745-ft. contour. The down draw is planned at from 12 to 14 ft., with a draw of 28 ft. the maximum possible once in forty years, indicated by existing records. Floods are expected never to raise the water above the 750-ft. contour. Flood waters will not be permitted to leave the river bed below the dam, which is expected to lower the Mississippi flood level one foot at New Orleans.

The Massman Construction Co., Kansas City, Mo., has the general contract, at a figure of $9,322,960. Land is being purchased from four thousand individual owners and one town, Bernice, Oklahoma, will be submerged, with mass evacuation planned for January 1, 1940.

The Grand River Dam has produced something unique in the history of damsite towns, Disney, at the east end site, named for Oklahoma Congressman W. E. Disney.

Benson Boiler Developments*

Variable pressure operation, simple construction, low cost and flexibility feature of the Benson boiler which now constitute over a third of the high pressure boilers ordered in Germany

BY FRANCIS HODGKINSON
New York, N. Y.

DURING the early development of the Benson boiler it was supposed that a "once through" boiler must, to insure stability, operate at least with critical pressure, but in practice the critical pressure was throttled to 1500 to 2500 lb. per sq. in., for use in the prime mover. About 1933 it was learned that this type of boiler could be operated at any pressure above say 500 lb. per sq. in., which resulted in the development in Germany of a system of operation with variable pressure, the pressure being caused to vary in response to load demand.

The principle of operating with variable pressure presented a simplification of the turbine, inasmuch as, except for an emergency governor to prevent overspeeding, there is no need of valve gear controlling steam flow at the inlet to the turbine, although means responsive to the speed of the turbine may be employed for controlling feedwater supply and elements of combustion. This principle permits the turbine to sustain enormous overloads without the addition of any special valve gear or by-passing means.

It is significant that when operating with variable pressure and with proper allowance for vacuum variation with load, the isentropic heat drop to condenser pressure remains approximately constant down to low fractions of output. Also the total steam volume remains constant so that, except for the lowest pressure elements, the turbine proportions are appropriate for any output and the turbine therefore has a nearly constant efficiency.

It seemed that the exploitation could be best accomplished by the most intimate collaboration between the boiler and turbine apparatus designers, rather than by a boiler manufacturer alone. In 1933 the Westinghouse Co. acquired an exclusive license. That the company, for good reasons satisfactory to itself, decided, at least temporarily, to abandon development, is beside the point as to the value of the German development which should prove interesting to American engineers.

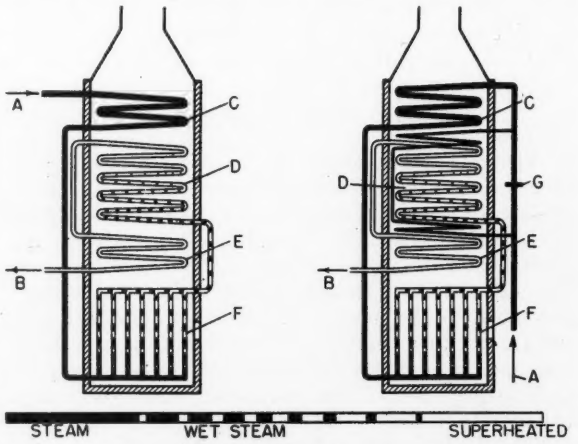
In its simplest form, the Benson boiler consists of a heated tube through which water is forced and evaporated and superheated during this process. In the first large installations salts in the feedwater deposited on the tube walls where the steam and water mixture changed to dry, saturated steam. This zone was in the radiant heat absorbing tubes where the tubes were exposed to the most intense heat. As a consequence, the tubes became overheated, and some of them burst after being in operation for a few days. After recognizing the real cause, that part of the heating surface, in which salts had been deposited, was relocated to zones of lower flue gas temperatures, so that an appreciable layer of salts did not result in any dangerous increase in the temperature of the tube walls. The improved arrangement of the heating surface resulting from the experiences mentioned in the foregoing is shown schematically in Fig. 1.

Salt deposits are now flushed out periodically. For this purpose, the boiler is shut down for a short period, and water is pumped through the tube system for about 1 hr. with a flow corresponding to about one-third of the normal boiler rating. The frequency of this flushing depends on the condition of the feedwater. In plants using condensate for the feedwater, and where distillate is used also for make-up water, the flushing need not be carried out more frequently than once in three months.

Carryover

With the advent of steam pressures of 1200 lb. per sq. in. and higher, difficulties have been experienced with drum-type boilers because of salts being carried into the turbine and choking the blade passages. Similar difficulties have been occasionally experienced with Benson boilers, but, it is stated, only when because of some inadvertence, raw water has leaked into the system.

Dr. Michel of the Hamburg-American Line, who has had ships equipped with Benson boilers under his charge, states that "The Benson boiler carries over less salts to the turbine than are fed into it since there are



Figs. 1 and 2. (Left) Schematic arrangement of Benson boiler with the transition zone, where salt deposits first caused tube trouble, moved from the radiant heat to a lower temperature zone. (Right) Addition of auxiliary heating surface for control of steam temperature. A, water inlet; B, superheated steam outlet; C, economizer; D, transition section; E, superheater; F, radiant heat section; G, throttling device

*From a paper presented before the A. S. M. E.

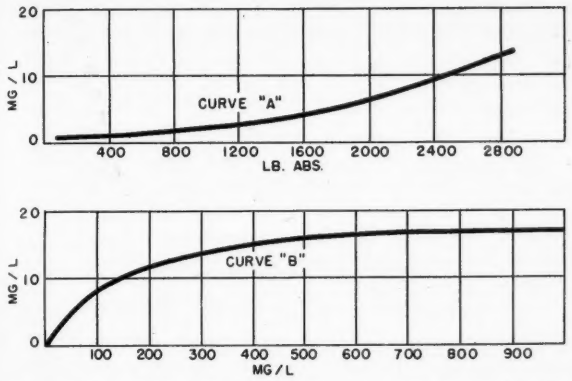


Fig. 3. Salt content of superheated steam from tests reported by Dr. Michel of the Hamburg-American line. Curve "a" is a function of the operating pressure at a total steam temperature of 800 deg. F. and 25 p.p.m. feedwater concentration. Curve "b" is a function of the feedwater concentration at 1400 lb. and 800 deg. F. operation

deposits in the tubes and, even at the highest ratings, there is no priming and foaming. The amount of salt carried over as a function of the salt concentration in the feedwater is shown in Fig. 3."

Considerable improvements have also been made in the Benson boiler control. With the Benson boiler, in homely language, one feeds water in response to load demand, and then fuel in response to a temperature indication. This statement must not be taken too literally, as obviously both fuel and water should be simultaneously adjusted in response to load demand with a correcting impulse in response to temperature. There is a certain interval of time between the moment combustion is changed and the moment the effect on the steam temperature becomes noticeable. A change in the firing of a Benson boiler can have its full effect on the steam temperature only after the feedwater has gone through the entire boiler, which takes 1½ to several minutes, depending on the load. An additional delay is caused by the heat inertia of the mass of metal of the superheater. It is obvious that under such conditions boiler operation is difficult, since temperature-controlled regulation will necessarily lag and result in over-regulation.

Control

This difficulty has been remedied by the use of an auxiliary heating surface, as shown in Fig. 2, which consists of a thin tube (of 0.39/0.63 in. diam.) connected in parallel with part of, and amounting to about 1/1000 of, the main heating surface. Water at high velocity, forced through the auxiliary tube, is only heated, not evaporated, and the flow being proportional to the total volume of water, the temperature rise is a direct measure of the heating of the main boiler.

Since it takes only about 10 sec. to pass through the auxiliary heating tube, changes in the firing can be discovered before they can have any effect on the steam temperature. Therefore, if the heat supply is regulated in such a way that the heating of the auxiliary tube remains constant, the main steam temperature will be held constant. As shown in Fig. 2, a throttling device is built into the feedwater pipe line between the connections to and from the auxiliary heating tube, so that the desired water velocities will be obtained. The auxiliary heating tube is now furnished with all Benson boilers and has operated satisfactorily in all installations thus equipped.

The regulation described above applies only to corrections of undesired changes of firing or feedwater volume, and is, of course, merely a corrective supplement to the normal load-controlled regulation of feedwater, fuel supply and air in their proper proportion. If fuel, air and water supply are adjusted simultaneously, the desired increase or decrease in the steam production is obtained practically at the instant the increased or decreased fuel supply becomes effective in the combustion chamber, and delays in regulation are depending solely on the flexibility of firing. Automatic control of a Benson boiler is not necessarily required, since half the boilers in operation are manually controlled. More than one system of automatic control is possible.

Due to the economical conditions in Germany, no new Benson boilers were installed in the years between 1929 and 1933. In the years of business recovery since 1933, however, the boiler industry experienced an exceptional upturn so that today there are in operation or under construction no fewer than 82 Benson boilers. Of 189 boiler orders placed in Germany for pressures of 1150 to 2150 lb., 58 were for Benson boilers.

The following types of firing are being provided for the boilers now under construction: 24 with Kraemer mills; 19 with blast-type mills and corner firing; 10 with powdered-coal firing, corner firing, central mill system; 1 with traveling grate stoker; 3 with underfeed stokers; oil firing for all marine boilers and boilers for testing purposes.

The materials employed for the tubing of Benson boilers vary somewhat with operating conditions, but typical steels are: for the water heating section, St 45.29, a normal carbon steel; for the radiation and transition sections TH 30, a molybdenum steel; for the superheater section TH 30 or CS 65, the latter a silicon-molybdenum-chromium steel. The heat release in the combustion chamber of a typical 55,000 lb. per

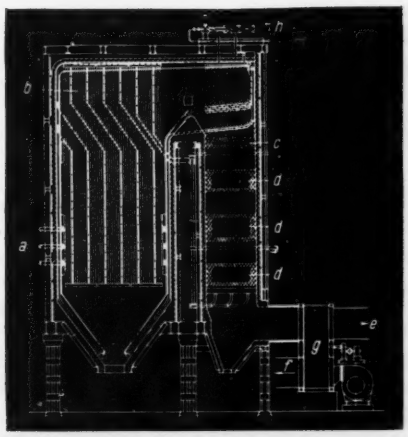


Fig. 4. Benson boiler designed for tangential firing; a, fuel burner; b, radiant section; c, superheater; d, transition section; e, to filter; f, to boiler; g, air heater; h, superheated steam outlet

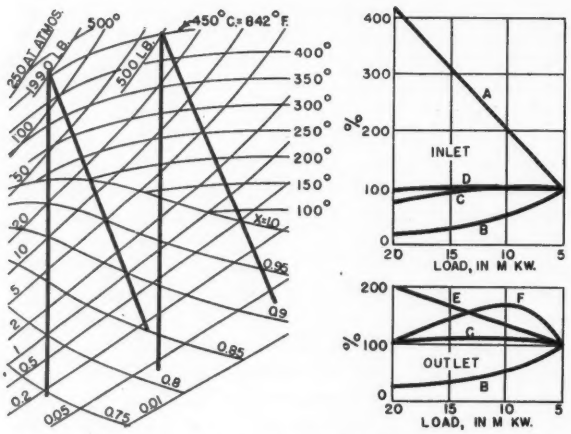


Fig. 5. Mollier diagram for a peak load station with variable pressure operation. The following legend applied to curves at the right: A, total steam flow; B, specific volume of steam; C, total steam volume; D, adiabatic heat drop; final moisture; F, exit losses

hr. unit at full load is 185,000 B.t.u. per cu. ft. per hr. In one case valve trouble was completely interrupted in the feedwater supply. In the absence of automatic alarm equipment, the boiler room crew did not discover the difficulty in time so that the steam temperature rose excessively and caused a defective superheater tube to burst. The tube was repaired in a few hours. The loss of feedwater experienced in this case would have had serious consequences with a drum-type boiler and, no doubt, would have caused a long interruption to service.

As has been mentioned before, the Benson boiler may be operated at any desired pressure and is of particular advantage at pressures above 570 lb. The boiler consisting only of comparatively small-size tubes, its cost is largely independent of the boiler pressure. German experience has shown that at 570 lb. the price of Benson boilers and normal drum-type boilers of equal rating is about the same. However, at 1400 lb. the Benson boiler cost is lower by about 20 per cent. The water storage capacity is not as small as is generally assumed, for example, a Benson boiler rated at 220,000 lb. per hr. and operating at a pressure of 1780 lb. can supply sudden load increases of 10 per cent above rated load for one minute at a pressure reduction of 10 per cent, or 178 lb. In cases where sudden and large fluctuations of load are expected, therefore, a type of firing should be provided that can be controlled sufficiently fast by a regulation system.

Variable Pressure

The fact that a Benson boiler may be operated at different pressures allows in many cases to employ the so-called variable pressure system of operation. The advantages of the variable pressure system lie not only in simplifying operation, but also in that the steam temperature at the turbine can be held constant for all loads, whereas in other cases the temperature decreases under partial-load operation due to throttling the steam in the regulating devices. Furthermore, the power required by the feedwater pump decreases considerably under partial-load operation. The final result is a favorable steam or heat consumption.

A simple back-pressure application for variable-pressure operation is where the generator feeds into a power system which can always absorb as much energy as the steam turbine is able to deliver in proportion to its steam flow. Here the steam flow depends solely upon the steam quantity required by the low-pressure or heating system. The turbine operates with regulating devices completely open but with the speed governor adjusted so that it becomes operative when the normal speed is exceeded by some prearranged amount. The boilers are regulated in response to the pressure in the lower-pressure system.

This method of operation is also possible in plants with complete or partial condensing operation and cross compound turbines. The frequency is controlled by the condensing turbine, while the high-pressure turbine utilizes all steam supplied by the boilers. In other words, load fluctuations in the electric system are first taken care of by the condensing turbine with the result that the intermediate pressure will show a tendency to change. This variation is used to regulate the boiler output either manually or automatically. This method is applicable in plants operating in parallel with others, and not required to maintain the frequency of the system. In isolated plants or plants controlling frequency, however, the variable pressure method can be used only if sufficient storage capacity is present in the intermediate pressure system. In purely condensing plants, storage capacity may be made available in low-pressure boilers or other steam storage devices.

Peak Load Service

Another valuable feature of variable pressure operation is in low-cost designs for peak load plants which do not control frequency but operate on a load schedule. The design can be made such that base load as well as load peaks may be supplied at comparatively favorable steam consumption. Assume a plant with a base load of 5000 kw. or a multiple of this value, and a maximum peak of 20,000 kw. or a multiple thereof. If the pressure at the base load is taken as about 500 lb. at 842 deg. F., the peak load conditions will be 1990 lb. at the same temperature. This would not be possible without reheating if good vacuum were maintained. If, however, the condenser is designed so that it is appropriately dimensioned for 5000 kw., its vacuum will be correspondingly impaired at 20,000 kw. and for equal steam temperature an inconsiderable increase of the moisture in the steam will be obtained. If the steam temperature is increased for the peak load, as is quite possible with a Benson boiler, the moisture in the steam may be maintained at the same value as at 500 lb.

In plants which are not suitable for the variable-pressure method of operation, the ability of the Benson boiler to operate at different pressures can also be used to advantage. For example, in the case of a back-pressure plant with several turbines the generators may be overdimensioned somewhat and the turbines may be designed so that they can withstand a somewhat higher pressure, with the result that when one turbine is put out of commission, full output of the plant can be maintained if only the pressure is correspondingly increased.

Forced Draft for Underfeed Stoker

Fans Often Blamed Because of Poor Coal

BY J. R. DARNELL*

POWER plant operators would do well to gain a thorough knowledge of the fundamental principles governing the operation of mechanical draft fans, particularly those for forced draft with underfeed stokers. The importance of accurately determining the "duct characteristic" or "system resistance" is too little appreciated, for it is this "system resistance" which governs the performance of the fan for that particular installation. Sometime ago the chief engineer of a small plant asked me to look at a set of curves which he said showed the operation of a forced draft fan when used with underfeed stokers. These curves are here reproduced as Fig. 1 with approximately true system resistances added as straight dotted lines. These straight lines approximately parallel the curves "D" and "F" given by the chief engineer as his estimate of the system resistances.

H. F. Hagen, one of the foremost authorities on mechanical draft fans, says:

"An underfeed stoker offers a resistance to air flow different from that of any other load with which we have to deal. In every other case the pressure required varies as the square of the volume, that is to say, four times the pressure is needed to deliver twice the volume. With the underfeed stoker this is not so, and only twice the pressure is required for twice the volume.

*Consulting Engineer, Jenkins Petroleum Process Co. and Donnelly Process Corp.

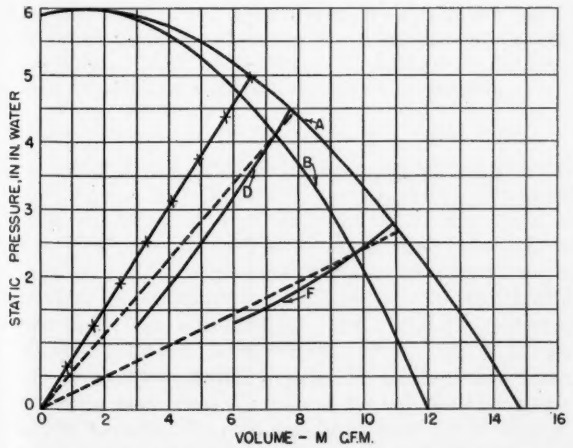


Fig. 1. Forced draft fan pressure characteristics and system resistances for one or two boilers

It is to be doubted that this so-called stoker curve is exactly a straight line. The grate openings and tuyeres, without the possibility of dispute obey the square law, and to get the straight line of the stoker the resistance of the fuel bed would have to decrease in just the right amount to overcome the increase of these constant parts. I understand, however, that the data have been secured from a large number of careful tests, and that the curve does closely approach a straight line in the range of usual loads."

The fact, however, that the system resistances should be straight lines instead of parabolas is not particularly important in the case of the fan performance discussed here because this would affect operation only at loads less than that at which the fan will deliver its maximum capacity. In this case the Chief said the fan not only was too small but a larger fan should have "a characteristic such that under the most severe operating conditions the pressure available would be in excess of that needed to overcome fuel bed resistance."

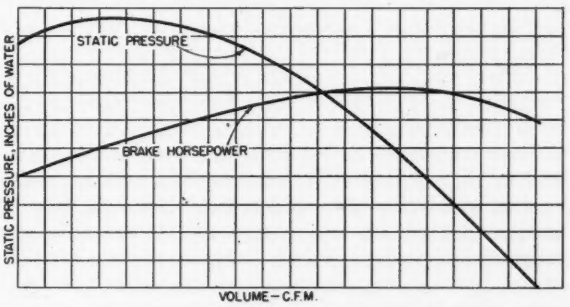


Fig. 2. Pressure and self-limiting power characteristics for forced draft fan with backwardly curved blades

Now his own curve of this fan shows that he was in error not only in recommending a larger fan but in the statement that the pressure available is a characteristic of the fan. The pressure available is a characteristic of the duct or system through which the air passes although it may be possible to have a fan which does not develop enough pressure at its maximum allowable speed at any point in its pressure curve to meet the pressure requirements of the job. In many cases, however, the fault lies in improperly estimating the system resistance and then basing the selection of the fan on this estimate. In some cases the resistance is underestimated, but just as often as not, it is overestimated. In the former case the purchaser will get a higher pressure than he specified but the volume will be less, less fuel can be burned and the boiler capacity will suffer.

In the latter case, where the system resistance has been overestimated, it is generally possible to develop greater capacity than had been estimated provided the fan prime mover is not overloaded. If the fan is of such design that it has a self-limiting horsepower characteristic, the prime mover, of course, will not be overloaded.

In Fig. 2 is shown a typical performance curve for a forced draft fan having such self-limiting power charactistic and in Fig. 3 is shown the characteristic of a fan which does not have the limiting power feature.

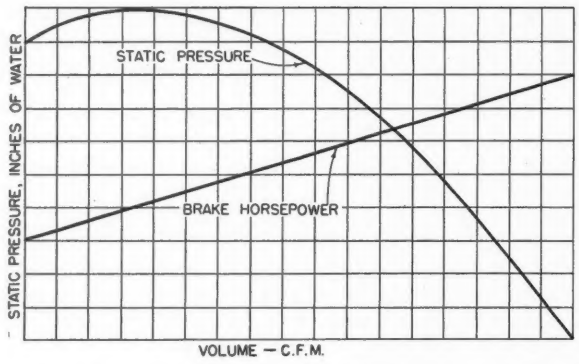


Fig. 3. Pressure and non-limiting power characteristics for forced draft fan with straight radial blades

In the case of the fan which I discussed with the Chief, the system resistance had been overestimated for both poor and good coal. This meant that a larger volume would pass through the system at a lower pressure than was originally expected. The estimated system resistance is shown in Fig. 1 by the line marked with crosses.

The Chief mentioned three operating difficulties, namely, "1. Inability to carry load and maintain desired steam pressure; 2. Excessive fuel consumption; 3. Smoke nuisance." He also gave three ways of correcting these troubles: 1. Purchase of a uniform grade of fuel of high quality and suitable for this type of stoker, which would only partly help; 2. Purchase of a larger forced draft fan with a characteristic such that under the most severe operating conditions the pressure available would be in excess of that needed to overcome fuel bed resistance; 3. Find some means of reducing the load on the boilers, either by the use of a larger and more efficient power unit or the purchase of power.

Now it is obvious to anyone who has had experience burning a poor grade of mid-western coal on an underfeed stoker that there would be just such troubles as itemized. To develop a maximum capacity of 800 b. hp., even with two boilers, it would be necessary to operate each boiler at 160 per cent rating. This does not appear to be an excessive rate of capacity, but there are a number of other factors which could cause trouble. The Chief did not state the number of square feet of grate area, so we are unable to calculate the combustion rate. This is the most important factor to be considered in burning of any solid fuel particularly one of poor grade having ash with a low fusion point.

Not knowing all of the conditions, of course, one cannot say just what could have been done to remedy the trouble, but it is doubtful if a mere change in the fan size or increased speed of the same fan would have materially changed the results. According to the data given by the Chief the system resistance, even with poor coal, for two boilers operating permitted approximately 9800 c.f.m. to pass through the system at a pressure of about 2.3 in. This corresponded to about 740 b. hp. With good coal the system delivered about 10,300 c.f.m. at 1.75 in., which indicated the development of about 780 b. hp. The slight increase in horsepower developed with the better coal and decreased resistance indicates, for one thing, that curve "B" Fig. 1, probably is in error even if there were not other factors which would indicate to the expert fan engineer that there scarcely could be sufficient data available to permit plotting curve "B" and for the same reason, the various parabolic system resistance curves.

It is possible, although not always probable, that operators can obtain accurate static pressure readings in the stoker wind box, but even assuming that a true static pressure reading is obtained, how can any operator, or even an expert, determine the volume corresponding to that pressure when the measurements are taken under the conditions as usually found in the field? Space does not permit discussion of the Fan Code requirements for correct volume measurement, but it may be safely said that in about 98 per cent of all fan installations direct measurement of volume is hopeless and any fan engineer who knows his business will not attempt it.

Knowing the troubles frequently encountered when burning mid-western coal on underfeed stokers my opinion would be, based on the incomplete data given, that 800 b. hp. could have been developed without any trouble if a good grade of eastern bituminous coal had been used. The Chief said that this would only partly help and if such statement had been made to the management it is little wonder there was no enthusiasm for this possible solution of the problem. It is quite possible that the capacity of the fan actually was reduced by frictional losses and there may have been some leakage, but if such was the case it could have been remedied with much greater ease than any of the other difficulties. Concrete ducts often show considerable leakage but this can be stopped by painting the inside with black asphaltum paint while under pressure. In one case it was found that a concrete duct with walls 6 in. thick showed about 35 per cent leakage before painting. Undetected leakage often occurs around the sides of the stoker, but this can be determined by the engineer if he will take the trouble to examine the stoker setting when the boiler is out of service.

Frictional resistance in the duct, in many cases can be remedied by properly shaped right angle turns or the use of straightening vanes. I recall one instance where the resistance was materially reduced in a con-

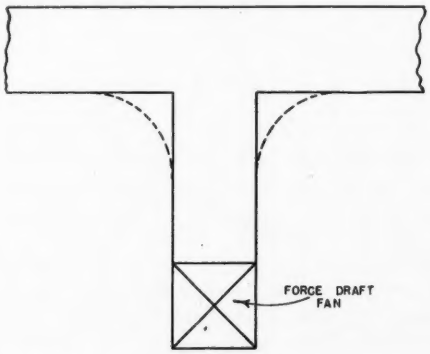


Fig. 4. Dotted lines show how fan discharge duct was modified to reduce friction losses

crete duct where the duct from the fan discharge entered another duct at right angles with air flowing both ways from the discharge duct as shown in Fig. 4. The corners of the duct were cut away as shown by the dotted lines. This permitted much better fan performance.

Returning to the problem submitted by the Chief I would say that the one and only satisfactory solution would be the burning of coal with considerably lower ash having higher fusion temperature. Even, however, with good grades of eastern bituminous coal, the sizing is of great importance and in many cases the moisture content is also important in getting good results. Space does not permit any prolonged discussion of the advantages of properly tempering coal by adding moisture, but I have personally conducted tests where good results were shown by tempering eastern coal fired on an underfeed stoker as well as satisfactory performance with tempered coal, both mid-western and eastern on traveling grate stokers. T. A. Marsh, in his book Combustion in the Power Plant says that properly tempered coal offers less resistance than either very dry or very wet coal, but even very wet coal offers less resistance than very dry coal.

The Chief mentioned the smoke nuisance as one of his operating difficulties and it is not surprising that this should occur when burning low grade mid-western coal on an underfeed stoker. It is quite improbable that this could have been overcome by higher fan pressure. On the other hand this higher pressure might have accentuated the trouble. Over-fire draft produced by high pressure air jets or induced by steam jets is the best way of solving the smoke trouble in such a case.

According to the Chief's statement the draft for carrying away the products of combustion was supplied by a stack which he said was ample for the requirements. Here again there is insufficient data to draw definite conclusions, but it seems that the draft loss through the boiler, as shown by the curve given in the performance chart, is considerably higher than it should be for the ordinary water tube boiler, presumably of three passes. Nothing was said about the available draft in the furnace at various loads.

It may be seen, therefore, that there are so many variable factors which may cause curtailed boiler capacity that the engineer seeking the cause should be very reluctant to blame either the forced or induced draft fan. Most of the time, as I have found from long experience, the trouble will be elsewhere.

TESTS RECENTLY reported on a La Mont high pressure boiler installed at the engineering works of G. & J. Weir, Ltd., at Cathcart, Scotland, show an overall efficiency of 86.46 per cent based on the gross calorific value of the fuel. Power absorbed by the auxiliaries amounted to 1.25 per cent of which 0.55 per cent was absorbed by the circulating pumps. Normal rating was 40,748 lb. per hr., 907.3 lb. per sq. in. gage and 877.2 deg. F. total temperature. Furnace heat release amounted to 39,760 B.t.u. per cu. ft. per hr. Gas temperature was 766.6 deg. F., leaving the boiler, which was reduced to 295.6 deg. F. at the economizer outlet.

Maintenance Cost of Power Equipment

By C. Leland Myers,
American Engineering Co.

IN THE two preceding articles* of this series, the importance of reliability and capacity as factors for consideration in the purchase of fuel burning equipment have been discussed. In this, the third article, our attention is focused on the maintenance cost of the proposed equipment, as the third important factor for consideration.

Although the actual dollars and cents cost for maintenance naturally has a bearing on total operating costs, maintenance cost achieves its chief significance not so much in itself as by reason of its influence on reliability. The cost of maintenance is at the most a few cents a ton against a coal cost of several dollars a ton. Therefore it is always secondary to the need for continuous operation.

It is advisable when considering maintenance cost to do so from this larger and more important aspect. The fundamental concern of plant management is low cost per thousand pounds of steam produced over a prolonged period. Although the cost of labor and material for repairs may be moderate, the consequent outage of the unit and the effect of outage on capacity, efficiency, economy, and other factors may be severe.

The most reliable method of determining the probable maintenance record of equipment under consideration, including the total cost of outage due to the necessity for repair, is to make a careful investigation of the performance record of similar equipment already installed and operating under similar conditions.

In addition to this investigation of performance, equipment should be examined from the viewpoint of (1) whether the repair or replacement of one part may be made with a minimum of disturbance of other parts, (2) whether provisions are made to allow the repair or replacement of a small part instead of a larger section or several parts, (3) whether repair parts are quickly available from the manufacturer of the equipment, and (4) whether the manufacturer has a record of parts development improvement.

TABLE SHOWING REPLACEMENT PARTS COST (NOT LABOR) IN EIGHT REPRESENTATIVE PLANTS

The significance of maintenance costs lies deeper than the figures indicate. The consequent outage and the effect of outage on capacity, efficiency, economy, and other factors are the primary consideration

	Replacement Cost, Dollars	Tons of Coal Burned	Replacement Cost per Ton, Cents	Period of Operation
PLANT A.....	172.80	28,835	.5	5 yr.
PLANT B.....	187.16	20,378	.9	5 yr.
PLANT C.....	3,371.90	160,567	2.1	1 yr.
PLANT D.....	3,712.50	128,975	2.8	5 yr.
PLANT E.....	5,645.00	166,915	3.3	8 yr.
PLANT F.....	52.10	45,542	.1	6 yr. 5 mo.
PLANT G.....	415.00	15,354	2.6	2 yr. 6 mo.
PLANT H.....	4,153.28	317,307	1.3	3 yr.

*Page 579 of September and Page 777 December 1938 issue of Power Plant Engineering.

Tests conducted indicate that combustion in small underfeed stokers is not a stable process even under conditions of continuous operation, it is not symmetrical with respect to the center line of the retort and removal of finer sizes does not materially affect burning characteristics of caking coals during continuous operating periods.

Combustion in Small Underfeed Stokers*

C. A. BARNES

Assistant Fuel Engineer, Fuels Division, Battelle Memorial Institute

SMALL underfeed stokers, by which is meant those burning 60 lb. of coal or less per hr. have gained increasingly rapid acceptance during the past 5 yr. Their use has spread to all parts of the country, and all ranks of coal from anthracite to lignite are being successfully burned with them. Despite their successful adaptation to such a wide variety of coals, difficulties are encountered with certain types of coals. The solution of these difficulties has been hampered because only the overall results of the process of combustion have been known and information on the details of the process of combustion within the fuel bed have been lacking.

A successful application of the fundamental principles of combustion as obtained from the studies of ideal fuel beds to the prediction of the operation of the small underfeed stoker requires more knowledge of the combustion process in the stoker itself than has been available in the past. To supply this information, a study has been made of the process of combustion in a typical small underfeed stoker. The research has been sponsored jointly by Bituminous Coal Research, Inc., the Battelle Memorial Institute, and has been conducted at the Institute.

*Abstract of paper presented at the Joint A. I. M. E. Coal and A. S. M. E. Fuels Meeting, Chicago, Ill. October 13-15, 1938.

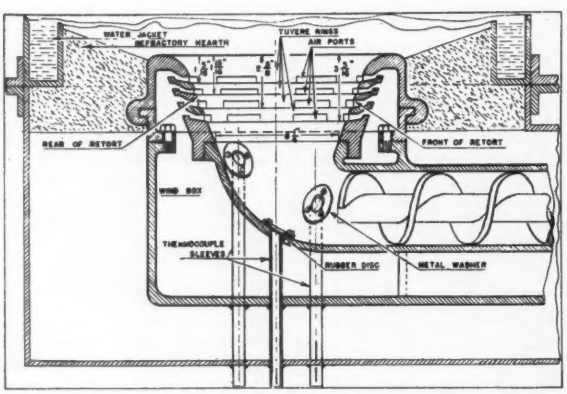


Fig. 1. Vertical section of underfeed stoker retort

As combustion is a chemical reaction, the progress of which is indicated by the composition and temperatures of the products of combustion, the work has been confined largely to measuring these quantities for known positions in the fuel bed. The studies were conducted with a typical pot-type, small underfeed stoker using high-temperature coke and bituminous coals from the Millers Creek and Pittsburgh seams. A range of burning conditions comparable to that of normal stoker operation has been investigated.

Figure 1 is a cross-sectional view of the retort showing the feed screw, the tuyere rings, and three of the five sleeves used for inserting the thermocouples. The tuyere rings could be replaced by blank rings so that both the area and position of the air ports could be adjusted within fixed limits. When less than four tuyere rings were used, the lower ring or rings were the ones replaced by blanks.

Combined thermocouple and gas-sampling probes in which pieces of three-hole, high-temperature refractory were soldered into seamless steel protecting tubes were developed for use in the fuel bed. With these it was possible to withdraw gas samples and measure temperatures simultaneously at positions in or above the retort. A minimum of 2 hr. was allowed for burning to reach equilibrium conditions before starting measurements in the bed. When the stack temperatures and the flue gas analysis indicated that a steady rate of combustion had been reached, a test probe was inserted into the fuel bed, temperature measurements were made, and gas samples were collected at different elevations through the combustion zone. Temperature measurements were cus-

tomarily taken at quarter or half-inch intervals. Gas samples were drawn off at intervals of from one-half to two inches. Three positions diagonally across the retort from front to rear were usually investigated. Some measurements were also made in a horizontal plane through the fuel bed above the top of the retort. As the burning conditions were never strictly constant, the measurements, once started, were completed as quickly as possible.

Fuels Used in Combustion Tests

Essential characteristics of the coke and of the two lots of coal used in the combustion tests are given in the accompanying Table.

Characteristics of Coke and Coals

Fuel Designation	High Temperature Coke	Coal: Millers Creek	Coal: Pittsburgh
Proximate Analysis, per cent			
Moisture	0.4	1.8	1.1
Volatile Matter	1.1	34.7	35.5
Fixed Carbon	89.3	59.3	54.9
Ash	9.2	4.2	8.5
Ultimate Analysis, per cent			
Carbon	87.1	77.9	74.5
Hydrogen	0.5	5.3	5.2
Nitrogen	1.0	1.6	1.5
Oxygen	1.6	10.1	8.1
Sulfur	0.6	0.9	2.2
Ash	9.2	4.2	8.5
Calorific Value, B.t.u./lb.	12,200	13,800	13,400
Air Required, lb./lb. fuel	10.15	10.45	10.14
Ash Characteristics, °F.			
Initial Deformation	2,100	2,050	2,020
Softening Temperature	2,530	2,210	2,350
Fluid Temperature	2,660	2,470	2,470

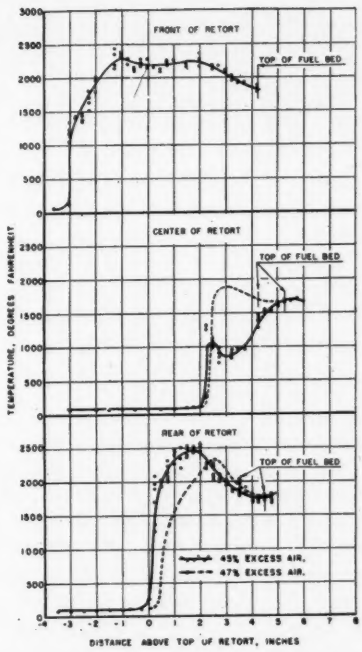


Fig. 2. Temperatures in the fuel bed for duplicate tests burning Millers Creeks coal

Coke is not commonly burned in underfeed stokers, but was used as it is convenient for test procedure and the results obtained are more easily interpreted. The size fraction used for most tests has been that passing a ¾-in. round-hole screen and retained on a 5/16-in. square mesh screen.

Millers Creek coal is a low-ash, free-burning coal and was used in the first tests on coal to avoid diffi-

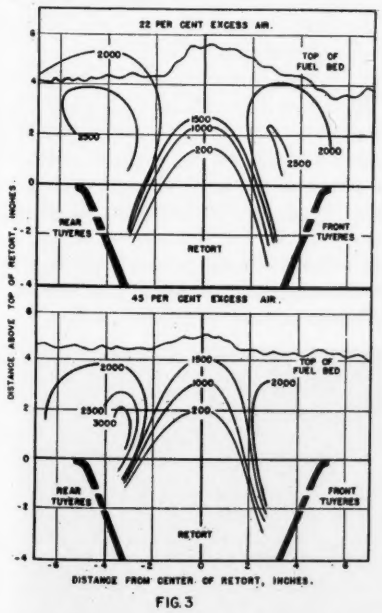


FIG. 3

Fig. 3. Isotherms in degrees Fahrenheit in a fuel bed using two tuyere rings when burning Millers Creek coal

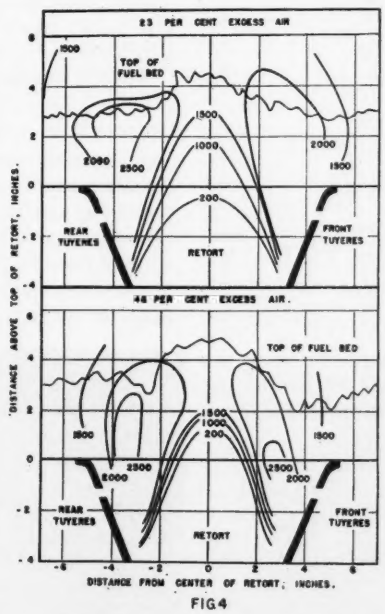


FIG. 4

Fig. 4. Isotherms in degrees Fahrenheit in a fuel bed of Millers Creek coal using one tuyere ring

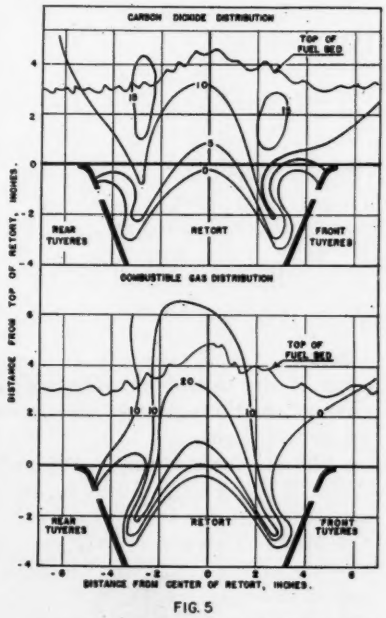


FIG. 5

Fig. 5. Distribution of carbon dioxide and combustible gases in a fuel bed using one tuyere ring, burning Millers Creek coal with 23 per cent excess air. Contour lines are drawn through points of equal percentage by volume of the respective gases

culty from caking and coking. The size fraction of Millers Creek coal used was 0 by 1 in. Pittsburgh seam coal was selected as an example of a rather strongly caking and coking coal often used in underfeed stokers. Four size lots—0 by ¾–, 0 by 1–, 0 by 1⅛–, and ⅜ by 1⅛-in. were used.

Summarizing the detailed explanation of the tests and analyses of the results, it may be said that fuel bed temperatures and gas compositions in the fuel bed have been determined for the small underfeed stoker burning high temperature coke and bituminous coal of both free burning and coking varieties. These measurements have been used to interpret the process of combustion in the underfeed stoker and lead to the following general conclusions:

The combustion of coal and coke in a small underfeed stoker is not a stable process even under conditions of continuous operation. The burning rates for different portions of the fuel bed as evidenced by fluctuations in temperatures and gas compositions in the fuel bed are continuously oscillating about some equilibrium value. Fluctuating stack temperatures show that the combustion rate of a fuel bed as a whole varies in a more or less cyclic manner with that found for fixed positions in the center of the bed. The unstable burning conditions limit the possibility of representation of average fuel bed conditions by the temperature and gas composition in the fuel bed.

Combustion in the fuel beds of both coal and coke fires is not symmetrical with respect to the center of the retort. At all normal rates of air supply, an excess of air passes through the front of the retort adjacent to the hopper, whereas a deficiency exists at the center and usually at the rear. The gases arising from the center and the rear of the fuel bed contain combustible that must be burned in the combustion space. More overfire combustion space is, therefore, required than if uniform mixing occurred within the fuel bed. An increase in the air rate increases the overfire air without necessarily improving the combustion in the fuel bed itself.

The maximum temperatures measured in fuel beds of coke were found in the center of the retort and ranged from 3000 to 3100 deg. F. Maximum temperatures for Millers Creek and Pittsburgh seam coals normally ranged from 2400 to 2800 deg. F. The zone of high burning rate for Millers Creek coal extended as an annular ring around a cone of comparatively cool fuel at the center of the retort. That of Pittsburgh coal was variously at the center or near the edge of the bed, depending upon the nature of the channeling through the coke structure at the time of measurement.

The thickness of the combustion zone ranged from 3½ to 5 in. for coke, 3 to 6 in. for Millers Creek coal, and 6 to 8 in. for Pittsburgh coal. The ignition level for Millers Creek coal varied from 2 to 4 in. below the top of the retort at the edges to well above the top of the retort at the center. The ignition level for coke was less curved and was generally near the top of the retort. That for Pittsburgh coal varied from the top of the retort to well above the top, depending upon the formation of the coke in the bed. Increasing the percentage of excess air decreased the thickness of the combustion zone, and for coke raised the ignition level with respect to the top of the retort. The trend was less definite with coal.

Fuel beds of different size lots of Pittsburgh seam coal were closely the same, indicating that the removal of the finer sizes from caking coals does not affect materially their burning characteristics during periods of continuous operation.

The rate of heating of the surface of fuel feeding to the ignition level during periods of continuous operation was computed as 250 deg. F. per minute. "Off" period rates were 100 deg. and 20 deg. per minute at distances below the ignition level of ½-in. and 1-in. respectively. Any tendency of the more rapid rate of heating to give more and stronger coke during periods of continuous operation will be largely offset by higher burning rates and by the action of the feeding fuel in breaking up the coke formed. Intermittent operation favors the formation of coke trees.

Underfeed stokers do not burn coke and coal strictly on the underfeed principle, but on a combination of underfeed, crossfeed and overfeed burning.

Electric Welder in Maintenance Work

POWER PLANTS have found electric welding a most effective means of lowering maintenance costs. This method permits making permanent repairs to broken or worn equipment in many instances for a fraction of the cost of replacement.

Among every-day instances of repair savings in power plants using arc welding are: mending cracked edges of expansion joints; fixing worn spots, broken lugs, and other details of soot ejectors; making repairs to pumps, stokers, chutes, hoppers, shafting, dump bodies, ash pans, pulleys, sprockets, gears, wheels, piping, zoned air systems, grab buckets, or any power plant accessory made of weldable metal.

Almost any repair job can be done easily and with greater economy by electric welding. All that the maintenance department need do is to move the arc welding machine to the work, or the work to the arc welding machine, place a suitable electrode in the electrode holder and weld up the break or build up the worn surfaces.

For resurfacing worn parts of power plant equipment, electrodes are made for providing wear resistance in every application.

Photo, The Lincoln Electric Co.
Grab bucket repaired by electric welding

Thumb Electric Cooperative, a $2,000,000 REA project, completes new Diesel station at Ubly, Mich. Three units with a combined capacity of 2100 kw. supply power to some 5000 farmer members in an area covering practically the entire Thumb district of Michigan.

More REA Power

ORGANIZED to serve some 5000 farmer members in Huron, Sanilac and Tuscola counties of Michigan, the Thumb Electric Cooperative was, on April 30, 1937, alloted $2,000,000, the largest allotment made by the REA. Some $300,000 of this was for a generating station which was finally located about ¾ mi. north of Ubly at the junction of highway M-19 and the Pere Marquette Railroad. With the advice and assistance of the REA, progress was rapid. The first pole was set Sept. 10, 1937, and the station formally opened on June 18, 1938. In addition to the station the project consists of two stepdown substations, some 57 mi. of 33 kv. transmission lines and 1300 mi. of 12.5 kv. transmission and distribution lines. Construction of short extensions is contemplated as requirements develop.

The station itself is of brick construction and the main engine room measures 76 by 55 ft., with a clearance of 17 ft. 6 in. from the floor to the highest position of the crane hook. A 12 ft. bay, 16 ft. high and 76 ft. long on the south side provides space for the circuit breakers behind the switchboard, a storeroom and washroom. An 8 ft. basement is excavated under the entire plant, including the 12 by 14 ft. office off the northeast corner.

Space for four generating units is available, but only three are installed. These are all Fairbanks-Morse Model 33D16 Diesels direct-connected to 2400 v., 3 ph., 60 cycle, 257 r.p.m. generators. Two of these generators rated at 736 kw. are driven by 7 cyl., 1050 hp. engines and the third, rated at 630 kw., by a 6 cyl., 900 hp. engine. Each generator has a 15 kw., 1450 r.p.m. v-belted exciter and an Allis-Chalmers rocking contact type voltage regulator.

The latter are grouped on a single panel on the main switchboard supplied complete (except for a General Electric synchroscope and Esterline Angus recording voltmeter and wattmeter) by Allis-Chalmers. It consists of 9 panels: three active and one spare generator panel; one regulator panel; one panel with the recording instruments; one 33 kv. feeder panel, one panel with two 12.5 kv. feeder circuits and one spare feeder panel. At the left of the main board is a swinging synchroscope panel and a cubicle with 12 Square D push button starters for the auxiliary motors and signal lights for the deepwell and air compressor motors. Six of these push buttons are on the cooling water pumps, three on the oil pumps and three are spares. From the 2400 v. bus in the station underground cables lead to the adjacent substation. Here two banks of Allis-Chalmers transformers are installed, one 1000 kv-a. bank feeds the 33 kv. circuit and a 750 kv-a. bank, two 12.5 kv. circuits. Auxiliary power and lights at 220 and 110 v. are supplied by a 112.5 kv-a. bank of Allis-Chalmers type transformers located in the basement immediately under the switchboard.

Each engine has a Woodward Type IC governor and S & K heat exchangers on the cooling water and lubricating oil system. These exchangers, together with all the other auxiliaries, are grouped in the basement along the north wall or at the head end of the engines, as shown by Fig. 3. The small elevation inserted in the space available for the fourth units shows the typical arrangement of the heat exchangers and lubricating oil systems. On the water side the exchang-

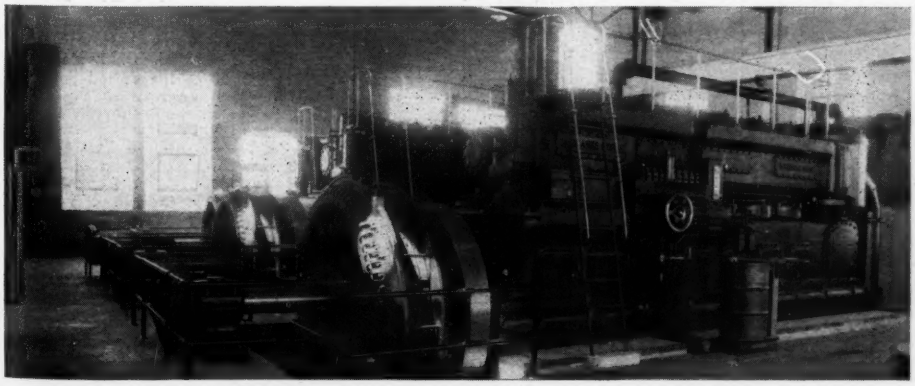


Fig. 1 Interior of the station taken while the acceptance tests of the engines were being made. Fuel consumed was weighed by the scale in the foreground and the power was absorbed in a water rheostat in the base of one of the cooling towers. The switchboard is set flush with the wall on the left

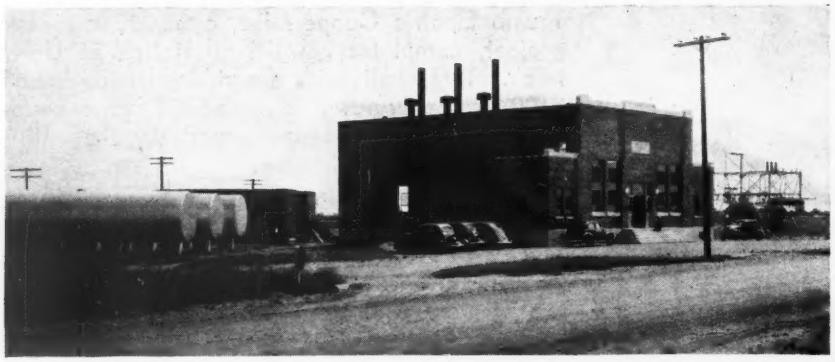


Fig. 2. The plant is located just north of Ubly at the junction of highway M-19 and Pere Marquette Railroad. The substation is at the right of the plant, the fuel oil tanks and cooling towers at the left

ers are piped in series with the oil coolers. An individual motor driven pump is installed to provide lubricating oil pressure before the engine starts and for cooling after it is stopped.

This pump is controlled by push button from a station on the operating floor. On the two outside engines the control panel carries in addition to the push button an Alnor multipoint pyrometer and three Marshalltown gages showing the fuel oil, lub. oil and scavenging air pressures. The panel for the middle engine is more complete. It has in addition gages showing the raw water, soft water and starting air pressures and push buttons for the six cooling water pumps which are tied into all three engines. These push buttons are duplicates of the ones adjacent to the main switchboard so that the principal auxiliaries can be started and stopped from two points. Failure of the cooling water or lubricating oil pressures is indicated on an alarm system hooked up with an Edwards annunciator system which indicates the location of the trouble.

A closed system of jacket cooling water is used with three F-M 600 g.p,m. centrifugal soft water and three 525 g.p.m. raw water pumps arranged in line along the north side of the basement wall as shown by Fig. 3. The three pumps of each kind take their suction from and discharge to a common header. A 150 gal. elevated expansion or surge tank on the discharge side of the soft water system on each engine provides for inequalities of flow and for some reserve capacity. Makeup for the soft water system is taken from the regular plant water supply system and treated by a Graver zeolite softener. The raw water is cooled in two Binks spray type cooling towers located at the back of the plant, each equipped with a 27,533 gal. concrete sump. Makeup is taken from the regular well water supply.

This consists of a F-M deepwell pump, installed in

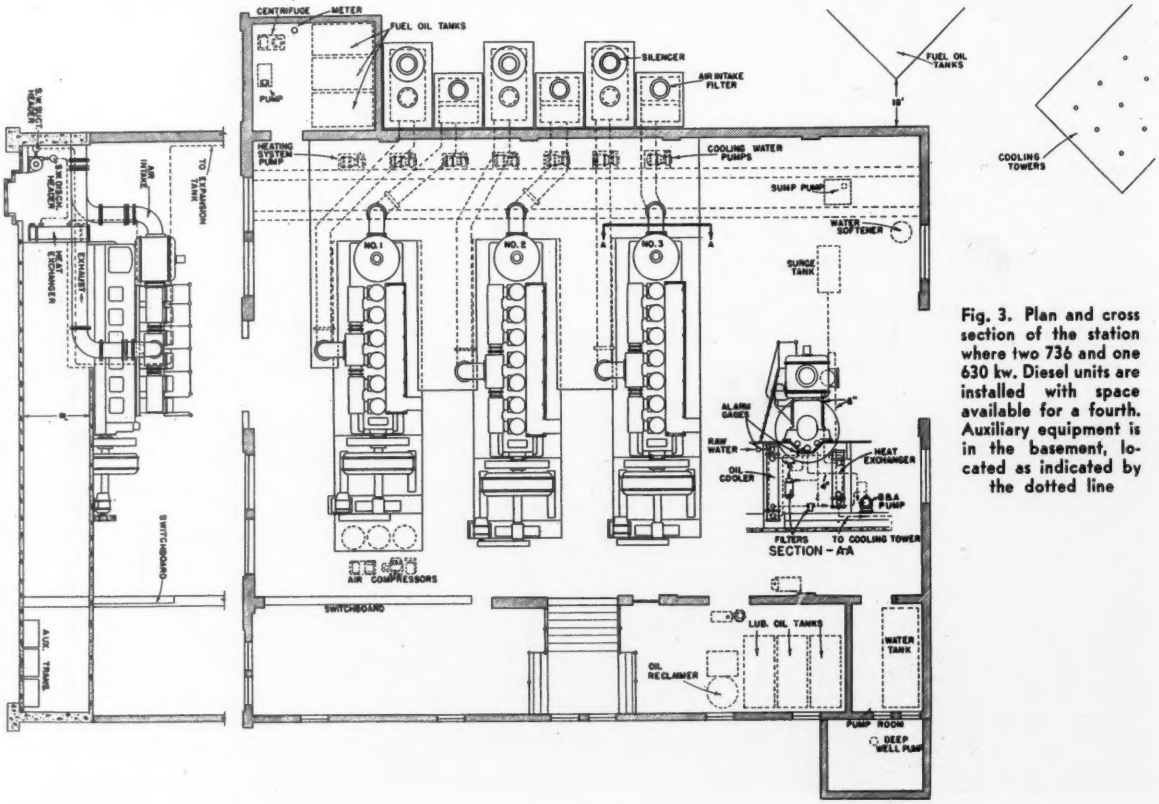


Fig. 3. Plan and cross section of the station where two 736 and one 630 kw. Diesel units are installed with space available for a fourth. Auxiliary equipment is in the basement, located as indicated by the dotted line

a well sunk to a depth of 433 ft., discharging to a 1500 gallon water tank in the basement. The pump motor is controlled by a Cutler Hammer pressure switch and the tank is interconnected with the compressed air system so that pressure can be maintained from this source so as to provide emergency service if the pump is not operating. This air is taken from the starting system which consists of 3 receivers at the generator end of Unit No. 1 and two Gardner-Denver compressors, one motor, the other gas engine driven. The total hardness of the well water runs around 16 gr. per gal.

Fuel oil which may be received either by rail or motor truck is stored in three 30,000 gal. steel tanks installed above ground as shown by Fig. 1. A fourth tank of 5000 gal. capacity, hidden in the photograph by the larger ones, is installed for storage of oil, cleaned by passage through the Hydrol unit incorporated in the fuel systems. The Michigan fuel being used at present is, however, clean and centrifuging is dispensed with, oil being transferred direct from the storage tanks to the day tanks as needed. Liquidometer gages in the engine room near the office door indicate the fuel on hand in the three storage tanks.

These three day tanks with the Hydrol unit and transfer pump are installed in the basement under the office arranged as shown on the drawing. Diagonally across the basement are three lubricating oil tanks, transfer pumps and a Type A, Renuoil purifier. In this unit the dirty oil is mixed with Fullers earth, heated, agitated and then filtered.

The building is heated by five Warren-Webster unit heaters supplied with hot water from the jackets by means of a small American centrifugal pump located in the basement just west of the soft water pumps.

Air intakes and exhaust lines are brought in from the outside underneath the floor. A separate air intake with American air filters and a Maxim silencer are provided for each engine, installed along the north wall as shown by Fig. 1, both intake and exhaust stacks extending well above the roof.

Piping in the plant is painted in accordance with the following color code: Raw water, green; soft water, grey; clean lub. oil, yellow; dirty lub. oil from scraper rings, black; fuel oil, red; and compressed air, white.

Fig. 4. Unit heaters using warm jacket water are provided for cold weather.

Each engine is provided with an instrument panel, as shown above, with a fuel oil, scavenging air and lub. oil pressure gage, a multipoint pyrometer and push button starter for the b and a oil pump. The center engine panel, just behind the air intake in the photograph, has in addition to these, raw water, soft water and starting air power gages, starters for the six cooling water pumps and annunciator tied in with the alarm system. Duplicate push buttons for the auxiliaries are provided on a small panel adjacent to the main switchboard.

The Southern Michigan Engineering Co. acted as consulting engineer, and Don Decker, who has many years of experience in municipal Diesel plant operation, is chief engineer of the plant. Harry Grayson, whose applications include membership in The Amer. Society of Agricultural Engineers and in The Society for the Advancement of Management, is manager of the Thumb Electric Cooperative with headquarters at Ubly, Mich.

List of Equipment, Thumb Electric Cooperative, Ubly, Mich.

Consulting Engineers. Southern Michigan Eng. Co., Lansing, Mich.
Building Contractors. Henry C. Weber Const. Co., Bay City, Mich.
Diesels and Generating Equipment. Fairbanks, Morse Co., Chicago, Ill.
Switchgear, Switchboard and Sub-station Contractors. Commercial Eng. Co.
Line Construction. Schwaderer & Edison, Cass City, Mich. Ulen Contracting Corp., Lebanon, Ind.
Generating Sets. Fairbanks, Morse & Co. 3, Model 33 D 16 Diesels driving 2400 v., 3 ph., 60 cycle, 257 r.p.m. generators and 15 kw., 1450 r.p.m., v-belted exciters. Two 7 cyl., 1050 hp. engines driving 920 kv-a., 0.8 p.f. (736 kw.) generators, and one 6 cyl. 900 hp. engine driving a 787.5 kv-a., 0.8 p.f. (630 kw.) generator.
Governors. Woodward Governor Co.
Silencers. Maxim Silencer Co. Three.
Air Filters. American Air Filter Co., Inc.
Oil Coolers. Schutte & Koerting Co. Three, 6.36 sq. ft. of surface each.
Heat Exchangers. Schutte & Koerting Co. Three, 180 sq. ft. of surface each.
Air Compressors. Gardner-Denver Co. Two —one, 2¼ and 3¼ by 3½ in., 250 lb., 600 r.p.m. unit, v-belted to a F-M 5 hp., 1750 r.p.m. motor, the other driven by a F-M single cylinder 5 hp. Type 2 gasoline engine. Both equipped with Burgess intake
Lub. Oil Filters. Diesel Filter Co. (Astoria, Ore.). Five, Sentinal.
filters, Mercoid pressure switches and Consolidated-Ashcroft-Hancock relief valves.
Cooling Towers. The Binks Mfg. Co. Two, outdoor spray type with 27,533 gal. concrete sumps.
Softener. Graver Tank & Mfg Co., Inc.
Fuel Oil Filters. W. N. Nugent & Co. Three.
Lub. Oil Purifier. Diesel Service Co. (Ames, Ia.). Type A Renuoil purifier with the agitator driven by a ¼ hp. Century motor.
Fuel Oil Purifiers. Goulds Pumps, Inc. Hydroil driven by 1 hp. F-M motor.
Oil Meter. Buffalo Meter Co.
Water Heater. Buffalo Meter Co.
Pyrometers. Illinois Testing Laboratories, Inc. Alnor.
Indicating Pressure Gages. Marshalltown Gage Co.
Annunciator. Edwards & Co., Inc.
Tank Gages. The Liquidometer Corp.
Deepwell Pump. Fairbanks, Morse & Co. Driven by 7½ hp., 1740 r.p.m. vertical motor with Cutler-Hammer push buttons and pressure switch.
Soft Water Pumps. Fairbanks, Morse & Co. Three, 4 in. centrifugals, 600 g.p.m., 44 ft. head, driven by 10 hp., 1750 r.p.m. motors and Square D starters.
Raw Water Pumps. Fairbanks, Morse & Co. Three, 4 in. centrifugals, 525 g.p.m., 62 ft., head, each driven by a 15 hp., 1750 r.p.m. motor with Square D starters.
Fire Extinguishers. Walter Kidde & Co.
Heating System Pump. American-Marsh Pumps, Inc. One, 2 in. centrifugal, 40 g.p.m., 12 ft. head, driven by a Howell 2 hp., 1150 r.p.m. motor.
Sump Pump. Penberthy Injector Co. One, driven by a ¼ hp. F-M motor.
Fuel Oil Pump. Fairbanks, Morse & Co. Driven by a 1 hp. geared motor.
Lub. Oil Pumps. Fairbanks, Morse & Co. Two, each driven by 1 hp., 1750 r.p.m. motors with Square D starters.
Engine Lub. Oil Pump. Fairbanks, Morse & Co. Three, each driven by a 3 hp., 1750 r.p.m. motor.
Piping. National Tube Co.
Brass Valves. Crane Co.
Water Valves. Reading, Pratt & Cady.
Unit Heaters. Warren Webster & Co. Nesbilt Giant.
Electrical Panelboards. Square D Co. Three Saflex.
Transformers. Allis-Chalmers Mfg. Co. Four, 333 kv-a. single phase, 2400/33,000 y. —19,200. Four, 250 kv-a. single phase 2400/7200 Y—12,500.
Auxiliary Transformers. Allis-Chalmers Mfg. Co. Three, 37.5 kv-a. each, 2400/110-220 v. air cooled type.
Switchboard. Allis-Chalmers Mfg. Co. Nine panels complete with rocking contact voltage regulators. 5 oil circuit breakers and indicating electrical instruments.
Watthour Meters. Sangamon Electric Co.
Synchroscope. General Electric Co.
Electric Clock. Warren Telechron Co.
Push Button Starters. Square D Co.
Crane. Shaw Box Crane & Hoist Co., Inc. 5 t.

High Speed Diesel Engines

By C. L. CUMMINS*
President, Cummins Engine Co.
Columbus, Ind.

UNTIL ABOUT the year 1916, little had been done toward anything that could be classed as a high-speed engine. In fact, the men of authority in those days were quite sure that 600 was the deadline for r.p.m. and that the Diesel could never take its place as a prime mover, except in stationary and possibly heavy marine service.

In 1919, we started production on what was the first real small-bore, high-speed compression-ignition engine. This little engine was rated one and one-half horsepower, with a bore of 3 in. and a stroke of 4½ in., turning at 800 r.p.m. for rated performance. This indicated that, so far as combustion was concerned, there was no reason why the engine could not be operated at a higher speed, but, for mechanical reasons, this was not done. We next developed a 4½ in. by 6 in. engine, which we very cautiously rated to turn at 800 r.p.m.

In 1930, one of these engines was placed in an automobile and found to operate just about as well at 1500 r.p.m. as it did at 800.

Merely stamping a higher rating on the name plate naturally will not result in a satisfactorily performing high-speed engine. As the r.p.m. goes up, the pressures invariably go up with it, torsional vibration creeps in, inertia forces become more serious, the problem of getting rid of the additional heat involved in working the parts oftener becomes serious, volumetric efficiency has to be looked into—in fact, the entire engine must go through a complete change. Therefore, most of the developments today in connection with high-speed engines are along some of these lines.

Higher speed calls for better bearing materials, more certain lubrication, harder surfaces on the journals, bigger and stiffer cranks to eliminate torsional vibration, better counterbalancing, in order to relieve center bearings of high loads, and general stiffening of the entire bearing structure insofar as the block is concerned.

Cylinder-head designs have had to undergo radical changes, in order to accommodate larger valve ports, to insure better cooling of exhaust valves, and to insure proper distribution of water, in order to eliminate localized hot spots, which will shortly lime up or cause cracked heads.

Liners have undergone many changes, in both theory and practice. The removable liner is becoming standard practice, and, as the load and speed go up, the necessity for the wet liner, or the type that is in direct contact with the cooling water, becomes more apparent. Liner materials and finish are constantly improving. Some fuel systems result in higher maximum pressures than others, and, in such engines, liners must of necessity be much harder. Finish in liners has gone beyond even best automobile practice.

The same material and design changes have taken place in piston rings. High speed means more problems for the oil regulating rings, and they have undergone constant changes. Piston design has probably suffered as many changes as any other part, due to the necessity for reducing weight as the speed has increased, and, at the same time, maintaining structural strength. In addition, the heat from the head of the piston must be rapidly dissipated, if the temperature at the ring belt is to be held below that point where gum forms, for excessive heat here is a major cause of stuck rings.

Connecting rod design has had to undergo considerable change. The old type marine rod has passed out of the picture. The necessity for extremely large, stiff crankshafts has increased the diameter of the crank pin to such a point that nothing except the very best of engineering and material will reduce the size of big-end bearings and enable the rod to be removed for maintenance through the cylinder bore.

Valves and cams have undergone constant changes and improvements. In the valves, it has been necessary to pay more attention to shape of head, the elimination of excess heat through stem design, and means to get the heat out of the valve guide into the water jacket as fast as possible. Operating mechanism for valves has naturally been lightened proportionately, in order to reduce inertia loads and take some of the burden off the valve springs and cams.

Cam designs have changed and followed the orthodox high-speed gasoline-engine construction, resulting in longer life of the parts and less noise at this point. Greater care must be taken in the design of valve springs, due to the larger range of operation, in order to eliminate critical surges in the spring.

In the development of the higher-speed engine, starting problems began to appear. The heavier engines were invariably started with air, but the trend today is toward the electric starting of engines. The starting problem, of course, is divided into two separate phases, cranking and starting. The cranking problem, of course, is mechanical and calls for enough energy to revolve the engine sufficiently fast to start firing. The starting problem, however, is a combination of the combustion chamber, turbulence, form of injection, etc. This differential between starting and cranking has not always been recognized by designing engineers.

In summing up the advantages of the high-speed engine and the problems involved in its development and maintenance, it would seem that the satisfactory performance in the field today indicates that not only is the high-speed engine here to stay, but that still higher speed, lighter weight and more flexibility in r.p.m. will be demanded in the future, unless history fails to repeat itself.

*Abstract of a paper presented at the Eleventh National Oil and Gas Power Meeting of the A.S.M.E.

This article is really a continuation of the article on feedwater heating by Mr. Keller which appeared in the December issue; as a matter of fact it was one article as Mr. Keller wrote it but it was too long to run in a single issue. So we split it up. In this part, the author continues his discussion of the economics of different systems of feedwater heating as related to turbine operation.

MODERN TURBINES*

By
ALLEN KELLER
Turbine Engineering Dept.
General Electric Co., Lynn, Mass.

WE HAVE SEEN from the discussion presented in the preceding installment of this series how easily the gain resulting from the use of feedwater heaters may be approximated. Let us now work out the theory which explains these gains in an equally understandable manner.

First of all, consider Fig. 4-A. This figure shows the percentage fuel saving for an ideal turbine operating with an ideal feedwater heating arrangement as compared to the same turbine operated without feed water heating. How was this curve derived?

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As stated previously, even under the best operating conditions about two-thirds of the heat supplied by the fuel is thrown away at the condenser, only about one-third being converted into power. For an ideal power plant operating without feedwater heaters, the portion of the heating value of the fuel which could be converted into power may be determined directly from the steam table.

Now, consider an ideal power plant operated with an infinite number of feedwater heaters and *saturated* steam at the boiler. Then the portion of the heat

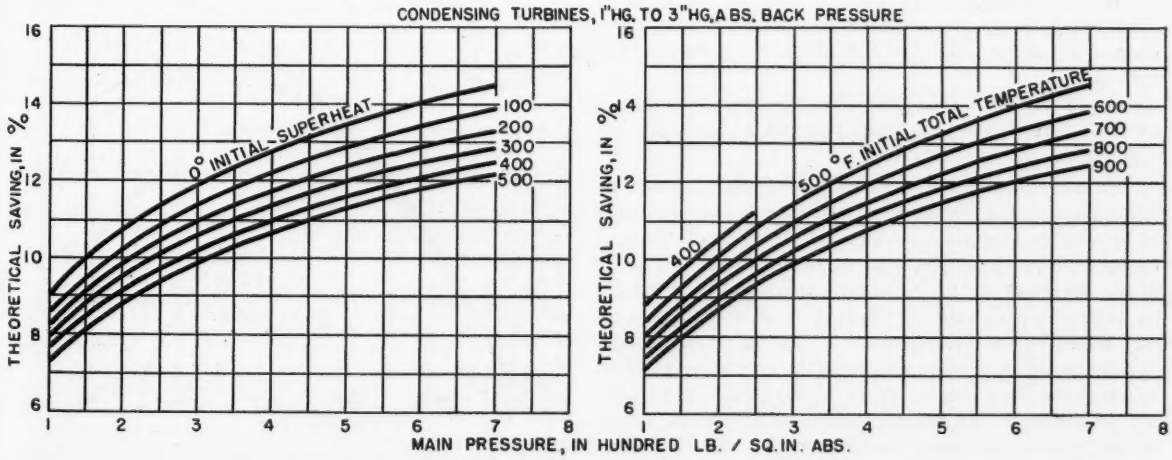


Fig. 4A and B. Approximate theoretical fuel saving resulting from feedwater heating

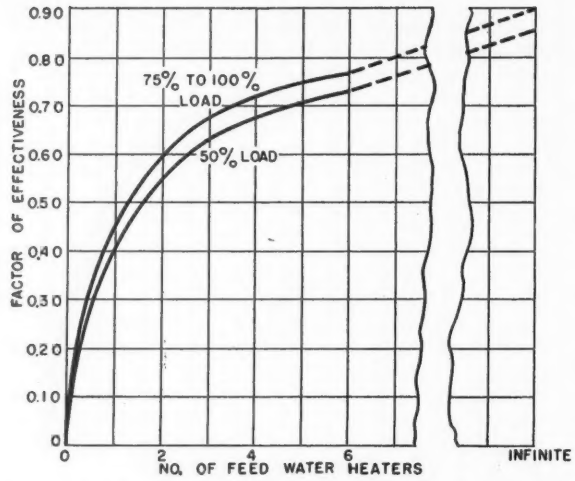


Fig. 5. Actual fuel saving by feedwater heating relative to theoretical saving for heat arrangement of heaters.

liberated by the fuel which can be converted into power is given by the equation

$$e = \frac{T_1 - T_2}{T_1}$$

where: e = The ratio of the heat converted into power to the heat supplied by the fuel.

T_1 = Absolute temperature at the boiler.

T_2 = Absolute temperature at the condenser.

(Absolute Temperature = Temp. in Deg. F. + 460).

Many readers will recognize this equation as the expression for the Carnot cycle efficiency. (Anyone not familiar with the Carnot cycle should keep right on reading, as this is going to be a non-technical discussion.) This efficiency is obtainable because all heat is added at a constant initial temperature, all heat is discharged at a constant final temperature, and all intermediate steps are reversible.

Thus on Fig. 4-A, with initially saturated steam, the theoretical gain by using feed water heaters was obtained by a direct comparison of values based on the steam table with the Carnot efficiency equation.

With initially superheated steam, the method of calculating the gain is somewhat more involved; however, the results may be plotted in the same simple form.

Chart 4-B was obtained directly from Chart 4-A by converting from superheat to total temperature according to the steam table.

Having obtained a curve showing the theoretical gain with an infinite number of heaters, the next step is to correct this for any desired number of heaters. Suppose, as an example, that we desire to use one stage of feedwater heating. In theory, this one heater might be supplied with steam extracted from the turbine at any desired pressure between the initial pressure and the condenser pressure. If steam were extracted from the turbine inlet, there would be no power generated by the extracted steam and consequently there would be no station efficiency improvement. On the other hand, if an attempt were made to extract steam from the condenser for feedwater heating, the extracted steam would be at the same temperature as the feed water from the condenser hot well, the feedwater would not be heated, no steam would be extracted, and there would be no fuel saving. It is apparent, then, that to effect a fuel saving, the steam must be extracted at some pressure between the turbine inlet and exhaust pressures. Now, as a first approximation, it seems logical that, with one heater, the maximum improvement will be obtained when an extraction pressure is selected which will heat the feedwater to a temperature half way between the condenser temperature and the boiler saturation temperature. In other words, with one stage of feed water heating, the heater should do the first half of the job and the boiler, itself, should do the second half. In like manner, we can reason that if two stages of feedwater heating are used, each heater should raise the temperature of the water one-third of the difference between the condenser temperature and the boiler saturation temperature, the boiler, itself, again performing the last step. If three heaters are used, each should heat the feedwater one-quarter of the total possible rise, and so on.

A detailed study of the feedwater heating problem[2] shows that the above reasoning is sound. As might be expected, however, there are practical considerations which affect the picture somewhat, with the result that the best temperature rise is only about 90 per cent of the value indicated by our reasoning.

Let us now consider the efficiency gain which might be expected from the use of these heaters. With one stage of feedwater heating, it was reasoned that one-half the heating should be done by the heater, the second half by the boiler itself. As an "off hand" judgment, then, one might think that the one heater arrangement with half the heating done by the heater would be about half as effective as an infinite number of heaters with all the heating done by the heaters. Similarly, with two stages of feedwater heating, each handling one-third of the temperature rise, the efficiency gain might be expected to be two-thirds that for

[2]Based on studies made in June, 1924, by A. W. Dull, J. H. Keenan, E. L. Robinson, and G. B. Warren of the General Electric Company.

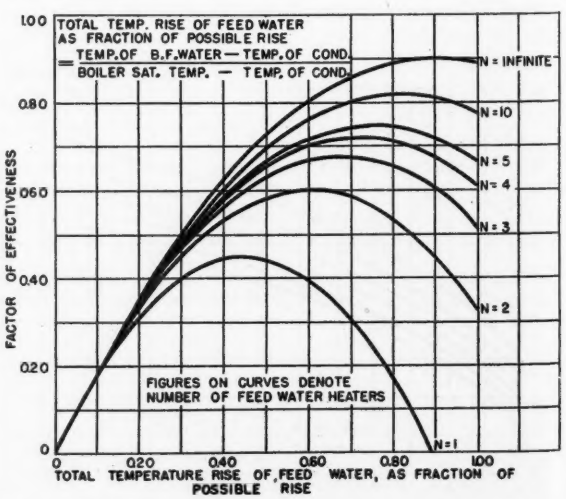


Fig. 6. Approximate effectiveness of feedwater heating vs. temperature rise and number of heaters

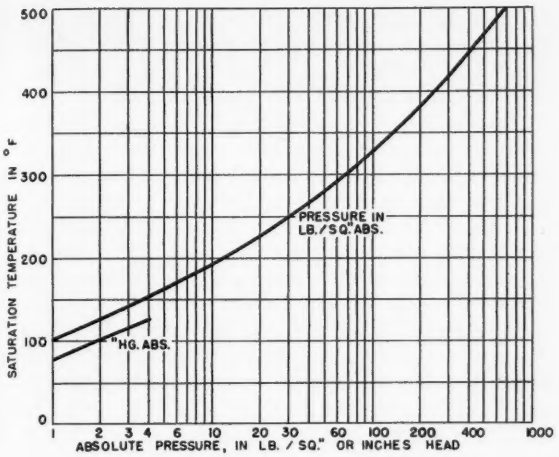


Fig. 7. Saturation temperature vs. pressure for steam

an infinite number of heaters. Three heaters should give three-quarters as much gain as an infinite number, and so on.

Again, there are practical considerations which make the actual gain somewhat less than the theoretical value. Detailed study shows the actual gain to be about 90 per cent of that indicated by the above reasoning.

Table A shows the approximate gain resulting from the use of different numbers of feedwater heaters, expressed as a fraction of the gain resulting from the use of an infinite number of heaters with an ideal turbine. The approximate best temperature rise for each heater and the best total temperature rise for the group of heaters are also given, expressed as fractions of the total temperature difference between the boiler saturation temperature and the condensate temperature.

TABLE A.

Number of Heaters.	Percentage of Theoretical Gain.	Best Temp. Rise in Each Heater, in Percent of Max. Possible Rise.	Best Temp. Rise for Group of Heaters, in Percent of Max. Possible Rise.
1	45	45	45
2	60	30	60
3	68	23	68
4	72	18	72
5	75	15	75
10	82	8	82
Infinite	90	Zero	90

Thus far, only cases where the feedwater is heated to the optimium temperature have been considered. Chart 6 [3] shows the effectiveness of feedwater heating under any condition of operation.

In turbine and steam table work, it has been found that many important functions follow the square law, that is, the extent by which the maximum gain fails to be realized varies as the square of the amount by which the optimum conditions fail to be fulfilled. If this be true, then small variations from the best feedwater temperature should not noticeably affect the overall plant economy. Detailed studies of heat balance diagrams substantiate this assumption, and, for this reason, it is not necessary for turbine manufacturers to design their machines for any exact feed water heating extraction pressures.

After the best extraction pressures have been selected, the turbine manufacturer may be permitted to choose the actual pressures which best fit in with other features of his design, with the knowledge that small variations of the extraction pressure will have no noticeable effect on the overall economy of the power plant.

Figure 5 was worked up from Fig. 6 on the basis that, at full load, the feedwater would be heated to its optimum temperature. At half load, the extraction pressures decrease, with the result that the feedwater will not be heated to its optimum temperature and the gain will be somewhat less than at full load. Also, the total feedwater temperature rise will no longer be divided equally among the various heaters. . . . At three-quarters load the loss relative to full load is slight, so that, for practical purposes, the full load curve may be used.

In order to estimate the size of pipes and other apparatus required to handle the steam extracted for feedwater heating, it is necessary to know the approximate extraction flows and extraction pressures. Fig. 7, a curve of saturation temperature versus pressure for steam, may be used for estimating extraction pressures. From this curve, the saturation temperatures corresponding to the turbine inlet pressure and to the condenser pressure may be read. The difference between these two temperatures is the maximum possible feedwater temperature rise. With any desired number of heaters, the best percentage temperature rise for each heater may be read from column 3 of Table A. This value multiplied by the maximum possible rise gives the temperature rise which should take place in each heater. Then by starting with the condenser temperature and making a number of successive additions of the temperature rise in each heater, the tempera-

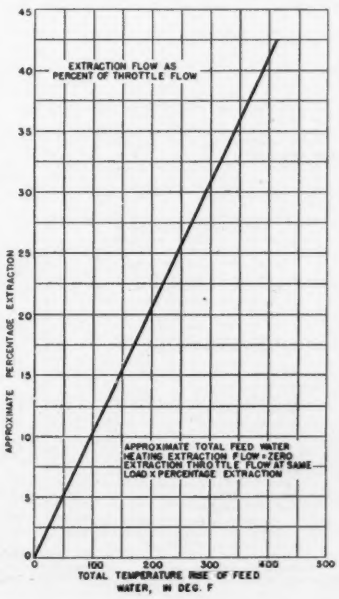


Fig. 8. Extraction flow as per cent of throttle flow

[3] Chart 6 is a plot of the equation, Factor of effectiveness $= \frac{0.90n}{n+1}\left[1 - \left(1 - \frac{R}{\frac{0.90n}{n+1}}\right)^2\right]$

n = number of heaters.
R = total temperature rise of feed water, as fraction of possible rise.

ture for each heater may be found. Finally, with these heater temperatures, the corresponding extraction pressures may be read from Chart 7. These pressures should normally be assigned to full load operation of the turbine. For other loads between half and full load, the extraction pressures will vary almost directly with the corresponding zero-extraction throttle flows.

Figure 8 shows the approximate total extraction flow required for feedwater heating, expressed as a function of the temperature rise of the feed water, in degrees. This chart gives the factor by which the full load throttle flow for operation without feedwater heating extraction must be multiplied in order to get the total extraction flow. The total extraction flow at full load may then be divided by the number of heaters used in order to determine the flow to each heater.

As the turbine load is decreased, the percentage extraction flow required by the low pressure heater will also decrease. When more than one heater is used, the percentage extraction required by each heater except the last will remain substantially constant for all power outputs between half and full load.

From the foregoing discussion it is apparent that there is nothing mysterious about feedwater heating nor why it results in increased power plant economy. The fuel savings which may be made in actual operation agree very closely with those predicted from a few simple theoretical considerations. Furthermore, the magnitude of those gains can be expressed on a few very simple charts. Of course, the data given in a general discussion such as this cannot be taken as the last word for any particular installation. It is believed, however, that the charts will be helpful for many preliminary investigations and, if optimum feedwater temperatures are used, the actual results will be very close to those indicated.

Prime Movers Production

MANUFACTURERS of engines, turbines, water wheels, and windmills in the United States reported large increases in employment, wages, and value of products for 1937 as compared with 1935, according to preliminary figures compiled from the returns of the recent Biennial Census of Manufactures, released by the Bureau of the Census, Department of Commerce.

Wage earners employed in this industry in 1937 numbered 32,860, an increase of 48.9 per cent over 22,062 reported for 1935, and, wages paid, $50,843,521, represented an increase of 89.4 per cent over $26,844,519, reported for 1935. The value of products of the industry for 1937 amounted to $194,695,037, an increase of 94.7 per cent over the 1935 figure. Of this total $108,094,440 was added by manufacture, more than double the 1935 value.

This industry, as constituted for Census purposes, embraces establishments engaged primarily in the manufacture of steam engines and turbines, internal-combustion engines of all kinds, water turbines and water wheels, windmills and windmill towers. This report does not cover the production of locomotives; of turbo-generators; of small steam turbines made for installation as parts of blowers, pumps, etc., or of engines made for installation in aircraft, ships and boats, motor vehicles, or tractors manufactured in the same plants.

Tabulation of engines, turbines and waterwheels manufactured in 1937 and reported in detail in the Biennial Census of Manufacturers. The notation[1] in the tables indicates the exclusion of engines made for installation in ships or vehicles manufactured by the same establishment

	Total			Number, by horsepower capacity (rated or normal, not overload)										
	Number	Rated horsepower capacity	Value	Less than 5	5 or more but under 10	10 or more but under 20	20 or more but under 50	50 or more but under 100	100 or more but under 200	200 or more but under 400	400 or more but under 600	600 or more but under 1,000	1,000 and under 5,000	5,000 and over
Steam engines:														
Marine reciprocating 1/	14	8,855	$193,117	---	---	---	1	1	2	2	3	2	3	---
Other reciprocating steam engines	557	116,534	1,545,179	9	27	134	97	53	20	26	158	43	8	---
Steam turbines:														
Marine	207	204,348	3,400,450	---	---	---	50	66	41	---	---	---	22	6
Other	2,471	963,627	12,860,673	251	324	465	492	290	263	138	109	53	84	30
Internal-combustion engines (except tractors):														
Injection engines:														
Compression-ignition (Diesel):														
Marine for direct connection to propeller shaft 1/	700	129,789	5,545,248	---	---	4	91	155	196	194	51	27	4	---
Marine for electric drive and auxiliary use 1/	214	50,436	3,314,522	---	---	41	55	42	32	6	10	9	19	---
Marine for connection to propeller shaft by reduction gearing	711	75,378	3,290,260	---	---	2	316	202	168	---	4	3	16	---
Stationary	5,942	592,505	17,300,765	60	208	896	885	2,871	1,765	316	56	57	38	---
Other Diesel (tractor, aircraft, railway Diesel-electric)	4,070	473,348	8,041,170	---	---	1	138	2,858	1,470	9	12	175	7	---
Surface-ignition, all types	8,462	366,535	4,083,428	371	14	3	6,125	1,672	273	3	---	---	---	---
Carburetor engines:														
Aircraft	6,214	2,599,385	28,576,971	---	---	---	1,504	126	373	1,276	507	2,331	17	---
Marine, inboard 1/	10,347	615,475	3,203,663	78	169	454	3,797	4,918	767	148	16	---	---	---
Marine, outboard 1/	77,549	387,522	4,359,822	65,605	8,188	1,227	2,543	8	---	---	---	---	---	---
Automobile 1/(including taxicab and light truck and bus)	92,651	3,206,212	6,946,794	---	---	---	82,470	3,080	7,083	18	---	---	---	---
Heavy truck and bus	12,465	1,123,894	4,330,403	---	---	---	725	7,619	4,139	---	---	---	---	---
Tractor engines made for sale separately	34,149	1,625,795	5,047,511	---	---	---	27,939	6,210	---	---	---	---	---	---
Railway cars	2,719	41,191	787,198	1,203	981	87	311	128	67	2	---	---	---	---
Industrial engines:														
Portable	52,071	735,815	5,849,491	30,711	5,474	4,068	5,781	2,823	1,186	8	---	---	---	---
Stationary	33,166	800,044	10,352,080	11,592	3,548	1,816	11,555	3,672	830	113	29	4	14	---
Other types of carburetor engines	254,979	8,626,078	13,538,877	201,849	3,079	5,828	22,633	20,309	1,312	89	---	---	---	---
Mixing valve engines	80,503	116,873	4,824,171	80,071	---	---	165	23	47	119	38	21	23	---
Water wheels and water turbines	225	508,218	2,967,042	53	9	16	21	17	18	27	13	13	19	19

Part XXXIII

In the application of the electric motor to industrial processes of various kinds the problem of speed control has always been one difficult of solution. In this field, the thyratron tube now brings an element of flexibility and efficiency which removes many of these old difficulties and gives new impetus to the art of control. A number of interesting circuits using these tubes developed by the General Electric Co. are described in this article.

ELECTRON TUBES— Principles and Applications

By A. W. KRAMER

AMONG the many industrial applications of electron tubes one of considerable interest is that in the field of motor control. The problem of motor control, especially alternating current motor control, has always been a difficult one and its solution in many instances has necessitated certain compromises.

Recently a number of circuits have been developed in which electron tubes, usually thyratron tubes, are used and these circuits in many cases provide definite advantages over older methods. While the use of tubes in this field is often competitive with older methods, there are some cases where other methods of control could not be used.

A number of these circuits were described in a paper by G. W. Garman of the General Electric Co., presented at the winter meeting of the American Institute of Electrical Engineers in January, 1938, and since these circuits are of direct interest to those who have followed this series, some of the more interesting ones will be described here.

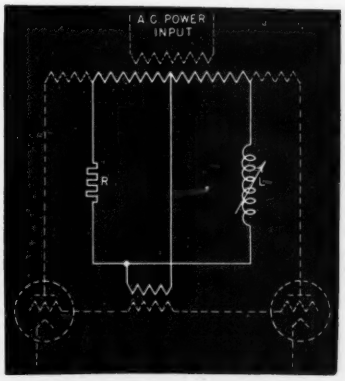


Fig. 1. Bridge circuit consisting of a resistor and a variable reactance for phase shift control of thyratrons

These circuits are used for the control of both direct and alternating current motors. Some utilize feed-back systems to hold the motor speed constant, but in general, their main function is to provide a smooth, adjustable control of the motor speed.

As pointed out above, while these methods of speed control by thyratrons are in competition with methods using rheostats, vibrating contacts, etc., the thyratron has the advantage of high efficiency, full control and quickness of response. The small control energy required and the quickness of response greatly simplify the design of precision control circuits and reduce the problem of hunting.

Circuits have been developed for both alternating and direct current motors but in this article we will consider only those for direct current motors. By means of these circuits it is possible to hold constant motor speed, constant armature voltage, or constant relative speed between two systems, It is also possible to hold constant either an alternating or direct current voltage which is dependent upon the speed or position of the armature of a direct current motor.

Feed-back Systems

The circuits developed by Mr. Garman can be divided into mechanical feed-back and electrical feed-back systems. In mechanical feed-back systems such as required in wire reeling applications where the tension of the wire is held constant, the position of a solenoid is varied mechanically with the effect that the speed of the controlled motor varies as the reel diameter changes or as the tension of the wire varies.

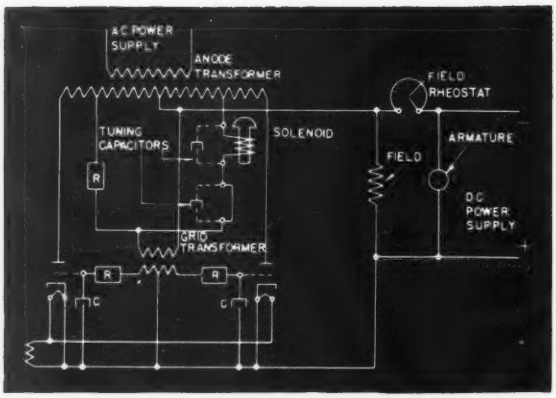


Fig. 2. Thyratron field control circuit with solenoid control

This is brought about by the change in inductance of the solenoid coil by the movement of the plunger. In electrical feed-back systems a voltage or current is used as a reference to maintain constant tension or speed or to hold the speed of the controlled motor at some definite relationship to the speed of another motor or system.

In these feed-back systems thyratrons are used as phase controlled rectifiers for furnishing either the field excitation or the armature power. Where a narrow speed range is required, field control is used but where a wide range is demanded or in cases where the time delay of the field circuit is objectionable, armature control is used. In either case the voltage impressed on the motor is not continuous but has a large ripple component.

While the effect of this ripple component is somewhat objectionable since it increases the loss in general its effect is not serious. When field control is used, the ripple effect can be neglected because of the smoothing effect of the field inductance. With armature control, it is advisable to provide a smoothing reactor since the inductance of the armature itself is low and produces no smoothing effect.

There is another effect in the case of armature control; current cannot flow from the thyratron into the armature circuit until the impressed sinusoidal voltage becomes greater than the counter electromotive force. For this reason unless a smoothing reactor is used the armature current may consist of a series of impulses which may increase sparking at the commutator and cause a rise in the temperature of the interpole windings. The interpole cores are usually not laminated and therefore are not suited to the alternating field created by the ripple component. Even with a smoothing reactor the armature current may be discontinuous at light loads but the effect can be made negligible by various methods. These characteristics are mentioned here to indicate the nature of some of the difficulties that must be overcome in putting these circuits to successful use.

Method of Thyratron Control

The output of the thyratrons is controlled by varying the apparent phase of the grid voltage. As pointed out in preceding chapters[1] several methods are available for accomplishing this phase control but one of the simplest is by the use of a variable reactor in a resistance reactance bridge circuit. Such a bridge circuit is shown in Fig. 1. This circuit consists of a resistance R and a variable L connected across the central portion of the reactor secondary of a transformer winding with the mid-points connected in series with the primary of the grid-voltage transformer supplying the grids of the thyratrons. By varying the value of the reactance, the reactance of the bridge circuit can be varied from zero to infinity and in this way the voltage from the mid-point of the bridge power supply to the junction of the register R and the reactance L will vary from the "in phase" position to 180 deg. lagging with reference to the applied voltage. By variation of the reactance L, therefore, the d. c. output of the thyratrons can be controlled over their entire range.

This type of control is used in both the mechanical and electrical feed-back motor control circuits. In the mechanical feed-back system a solenoid serves as the variable reactance element. As the plunger is moved in and out of the coil the reactance of the circuit varies.

A complete mechanical feed-back motor control circuit is shown in Fig. 2. In this circuit, the excitation as furnished by the thyratrons is in the same direction as that obtained from the direct current power supply. Should a thyratron fail, the maximum speed of the motor is limited to that value as determined by the setting of the field rheostat and in normal applications is approximately ten per cent above the normal maximum speed.

The curves A, B and C in Fig. 3, taken from G. W. Garman's paper previously referred to, show the variation in speed for different settings of the solenoid, and curves A^1, B^1 and C^1 show the variation in the thyra-

[1]Parts VIII and IX, September and October 1936 issues respectively.

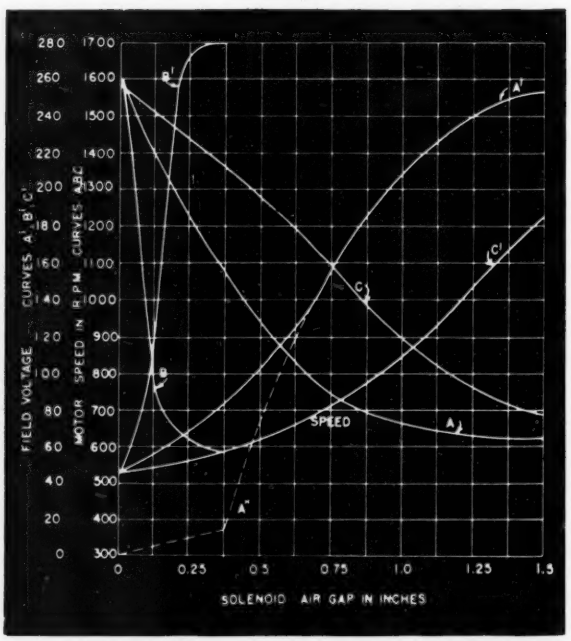


Fig. 3. Motor speed and field voltage curves for circuit shown in Fig. 2

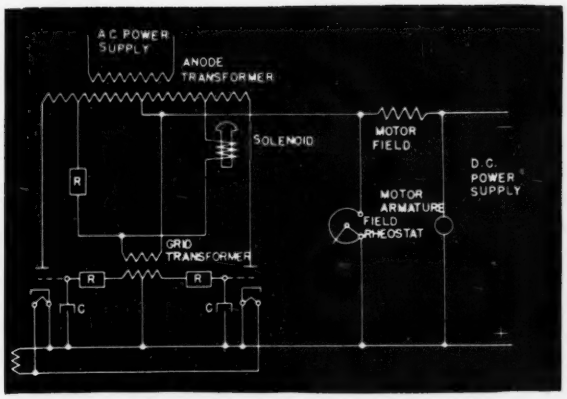


Fig. 4. Thyratron field reducing control circuit with solenoid control

tron output or field voltage. By partially tuning the solenoid with capacitors, as shown by the dotted lines in Fig. 2, it is possible to obtain the same degree of control with a smaller variation in the movement of the solenoid core. The untuned characteristics are shown in curves A and A^1 and the limiting tuned characteristics are shown in curves B and B^1. Curves C and C^1 show how these characteristics may be modified still further by changing the value of the fixed resistor in the phase shifting circuit. While these characteristic curves are not linear, their departure usually will not cause any difficulties. In a few cases where a linear relationship is required a correcting cam can be used.

Field Reducing Control

The control circuit in Fig. 2 uses the thyratrons to increase the field excitation of the motor, and as pointed out, in case of failure of the tubes, the motor speeds up to the value determined by the setting of the field rheostat. While the probabilities of tube failure are rather remote there are a few applications where it is desirable to reduce the motor speed to its basic value in case of thyratron failure. This can be done by arranging the circuit as shown in Fig. 4. Here the field rheostat is placed directly across the thyratron circuit and the excitation is controlled indirectly by varying the voltage drop in the field rheostat. With this arrangement failure of the thyratron tubes will cause the motor speed to decrease to its minimum value as determined by the setting of the field rheostat.

In the use of this circuit, the anode transformer must be designed correctly to limit the voltage applied to the field rheostat to such a value that the field current will not be reduced below its safe value, other wise the motor will run away. As will be evident, the utility factor of this circuit is reduced because the change in motor field excitation is obtained indirectly. The maximum thyratron current will be approximately twice the rating of the motor field.

Armature Control

In cases where armature control is necessary the circuit shown in Fig. 5 has been developed. In this circuit also a solenoid is used to vary the output voltage. The field excitation can be obtained either from a separate direct current source or from a pair of phanotrons as shown in Fig. 5. The phanotrons can use the same anode transformer as the thyratrons for their source of voltage.

As in other forms of armature control, some means must be provided to prevent suddenly impressing full voltage on the armature. This can be guarded against by various methods. As shown in Fig. 5, a pair of contacts can be mounted on the solenoid that are connected in the coil circuit of an anode contactor and are closed only when the solenoid air gap is reduced to zero, corresponding to zero armature voltage. By means of an electrical interlock on the anode contactor, the contactor is held in the closed position after the motor is started. If for any reason this method of protection cannot be used, a standard direct current motor starter can be used.

The characteristics of this type of control are shown in the curves in Fig. 6.

These mechanical feed back circuits have been found very useful in wire drawing, the making of celluloid, rubber and rubber fabrics. In these processes the problem is to hold the tension constant as the material passes from one part to another part of the same machine, or from one machine to another even though the driving speed of one part of the machine may vary. In case the material is being wound on a reel it is necessary to change the speed of the reel drive motor as the diameter increases. In this case the phase shifting solenoid is mechanically connected to a rider roll which rests on the material. If the tension is above normal the rider rises, thereby changing the solenoid air gap, which in turn either increases or decreases the thyratron output voltage, restoring the motor speed to the correct value. If the reel drive motor tends to run slow, the tension will be decreased and the rider roll will lower, producing the opposite effect.

As pointed out in the original A.I.E.E. paper, in which these circuits were described, the important point is that this type of control not only is capable

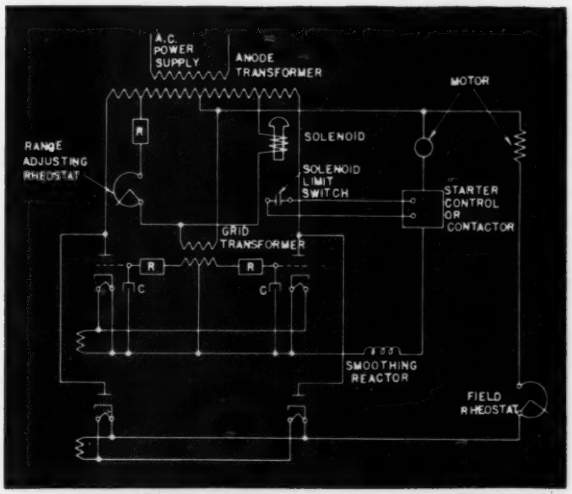


Fig. 5. Thyratron armature control circuit with solenoid control

of maintaining constant tension, but also provides a synchronous drive. In some applications constant tension is of minor importance and synchronism of major importance. In the case of reel drive, where it is necessary to decrease the speed of the driving motor as the reel diameter increases, the solenoid rider roll can be used in the same way. In such cases, however, it may be necessary to make adjustment for the difference in the range of travel between that of the rider roll and the solenoid core. If the variation in reel diameter is large a reducing system such as that suggested in Fig. 7 may be devised.

These methods of control are applicable over a wide range of capacities. Although the particular motors considered in this discussion were rated at 1½ hp., the control elements involved can be used to control the field excitation of motors up to 100 hp. and the armature power of motors up to 3 hp. Larger thyratron tubes can be used, but since these require appreciable amounts of grid power, the elements in the control circuit will have to be of higher rating when such tubes are used.

In the use of these circuits, the magnitude of the thyratron grid voltage must be large enough to compensate for variations in the critical grid voltage caused by usage and changes in temperature. It is possible to reduce these variations by replacing one of the thyratrons in the circuit with a phanotron and connecting one side of the field circuit to the anode of the phanotron instead of to the midpoint of the anode transformer. With this arrangement it is necessary to control only one tube.

On the whole these circuits provide an extremely

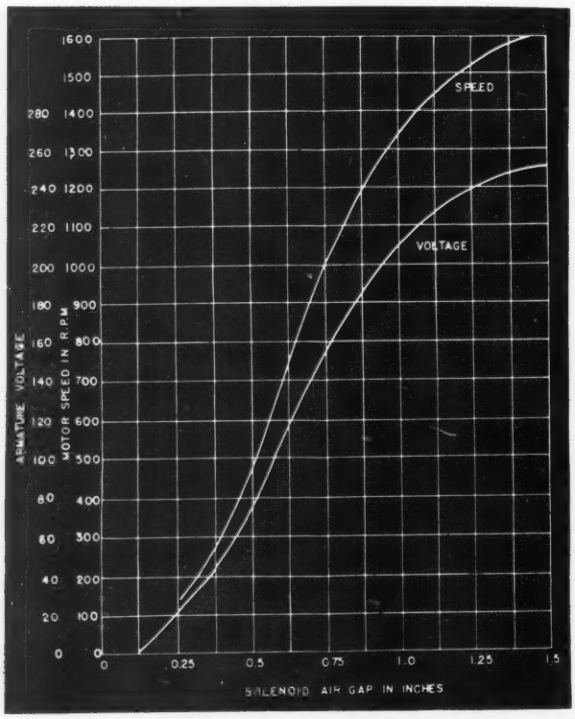


Fig. 6. Motor speed and armature voltage curves for Fig. 5

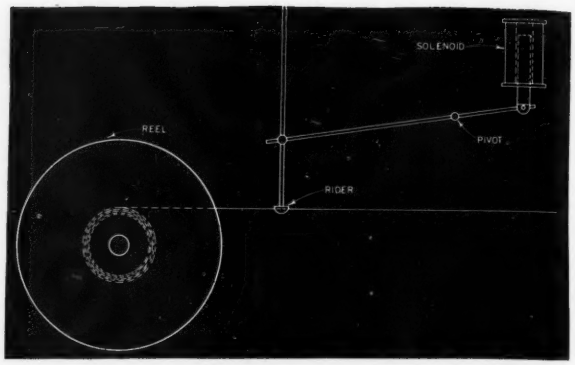


Fig. 7. Where the range of mechanical movement is great a reducing mechanism can be used

effective use of electron tubes in the industrial field. Although other methods of motor control might be used, the high efficiency and flexibility of these circuits have much to recommend them.

All of these circuits, it will be noted, use the mechanical feed-back system. In another article we will consider the other type of feed-back, that is, the electrical feed-back arrangement.

New Bonneville Units

BONNEVILLE is laid out for an ultimate installation of 10 or more units. The first step, with two 60,000 hp. (43,200 kw.), one 5000 hp. unit and a partial superstructure for four more units has been completed. The development is being engineered by the War Department and bids were received on Sept. 13 for two more units (Units Nos. 3 and 4) with accessories and embedded parts for two more (Units Nos. 5 and 6).

The new units, also single runner, propeller type wheels will be larger than the first two and will be designed to develop 74,000 hp. at 60 ft. head and not less than 34,000 hp. at 30 ft. head. The wheels, to be not less than 280 in. dia., will operate at 75 r.p.m. and drive 54,000 kw. generators. The embedded parts for units 5 and 6 consist of draft tube liners, throat rings, speed rings and pit liners. The extreme minimum head based on the 1894 flood is 22.8 ft. and the maximum head with natural tailwater is 67 ft. The wheels are, however, being designed for a maximum extreme head of 69 ft., possible with a regulated pool.

As a protection against pitting the specifications call for building up the periphery of the blades, including the tip, leading and trailing edges, with 18-8 or an equally corrosion resistant steel for a depth of at least ¾ in. The under sides of the blades for a distance of from 9 in. from the periphery toward the center must be built up with a similar overlay not less than ¼ in. thick. The runners must be guaranteed against excessive cavitation for a year and excessive corrosion is defined as the loss of 200 cu. in. or more per blade, or, a depth of ¼ in. or more at any place on the face of the blade. This does not cover loss from erosion due to suspended matter in the water or corrosion due to chemicals.

Capacitors Cut Body Plant's Power Bill

A CAREFULLY engineered group of General Electric Pyranol capacitors, installed six months ago in one of the Detroit plants of the Murray Corporation of America, has effected an average monthly saving of $1200 in power costs—enough to pay the total cost of the equipment in less than a year.

Greater production had necessitated increased electrical capacity to improve low-voltage conditions in the automobile body plant. Larger transformers and costly additional feeders could have been installed, but the Murray engineers decided that the same results would obtain with the capacitor installation, giving in addition an attractive saving in power costs.

The capacitors are located at 22 strategic points on various 440-v. power feeders. Inasmuch as no floor space was available, 12 equipments of 40 kv-a. each were mounted in existing service trenches beneath the main floor, and ten larger assemblies were suspended by ceiling hangers above the production area. Two other units, rated 120 kv-a., 4600 v., were mounted outdoors near transformer banks supplying part of the plant at 220 volts.

Assembled with disconnecting switches, each of the capacitor units was put into service merely by making the three wire connections. Overhead location of the units was permissible because the Pyranol-filled capacitors are fireproof.

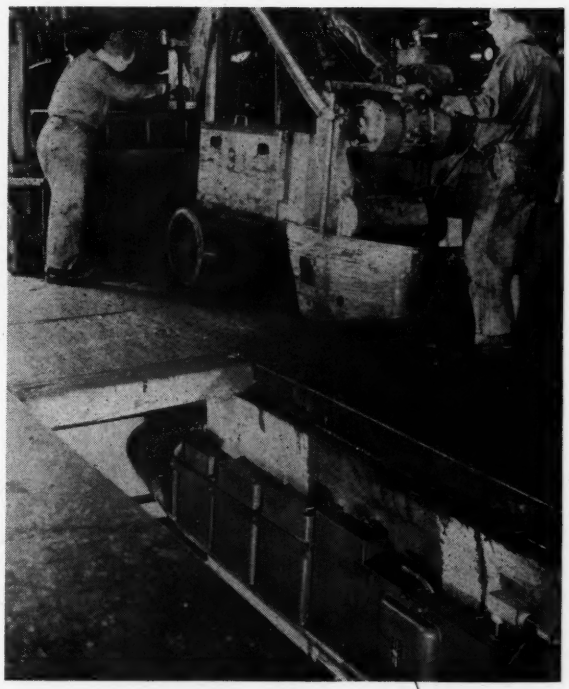


Fig. 2. Here the capacitors are installed in a service trench beneath the floor in the Murray plant. This includes 2 units of 15 kv-a. and 1 unit of 10 kv-a. with a rack and fusable switches

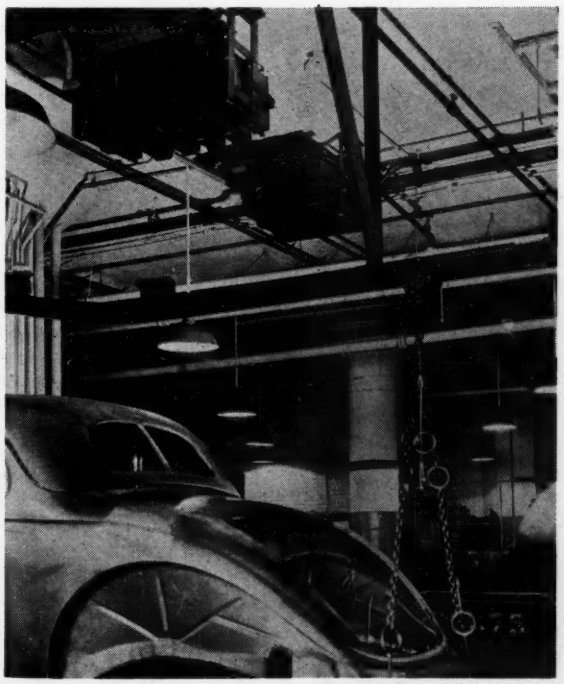
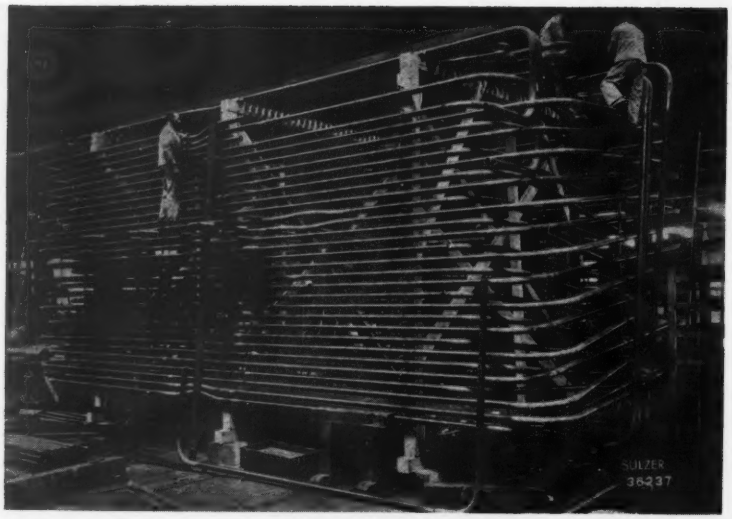


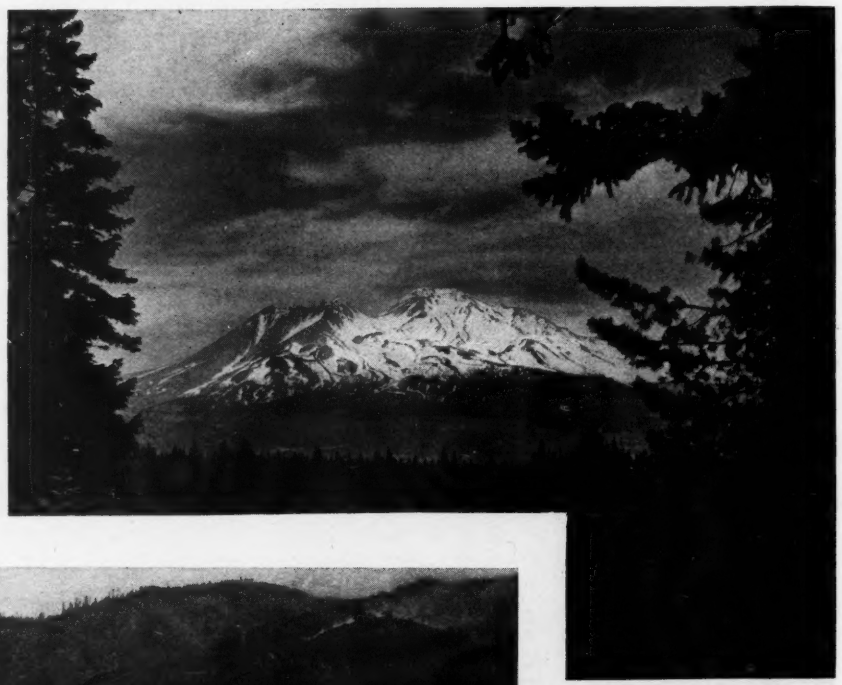
Fig. 1. Capacitor installation hung from ceiling in Murray body plant

Fig. 3. An outdoor capacitor installation at the Murray plant

PICTURES



Modern high pressure boilers or steam generators as they are called these days, are tending more and more to become single tubes with water entering at one end and steam leaving at the other end, thus the name, "once through" boilers. European developments in this field are quite notable and here we see the assembly of the combustion chamber of a Sulzer high pressure monotube steam generator for raising 70 tons of steam per hour to a pressure of 1550 lb. per sq. in. in the Sulzer Works at Winterthur. There is practically no storage capacity in boilers of this type and the flow of water into it is directly proportional to the steam leaving it

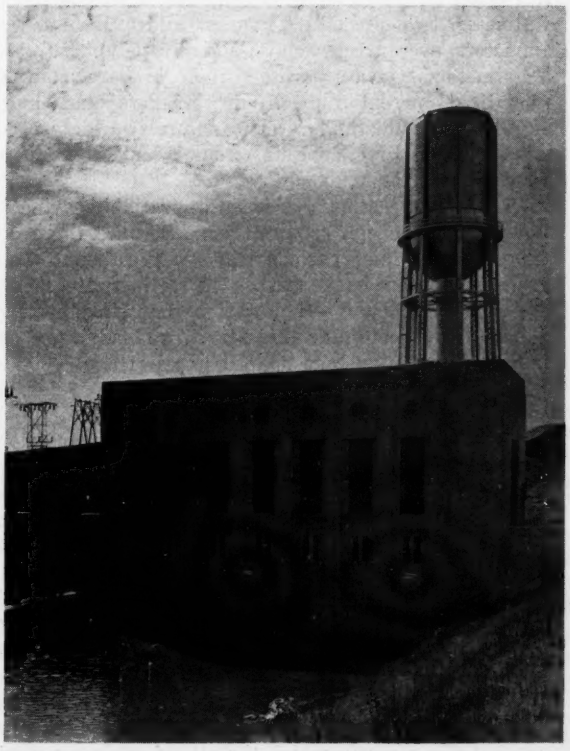


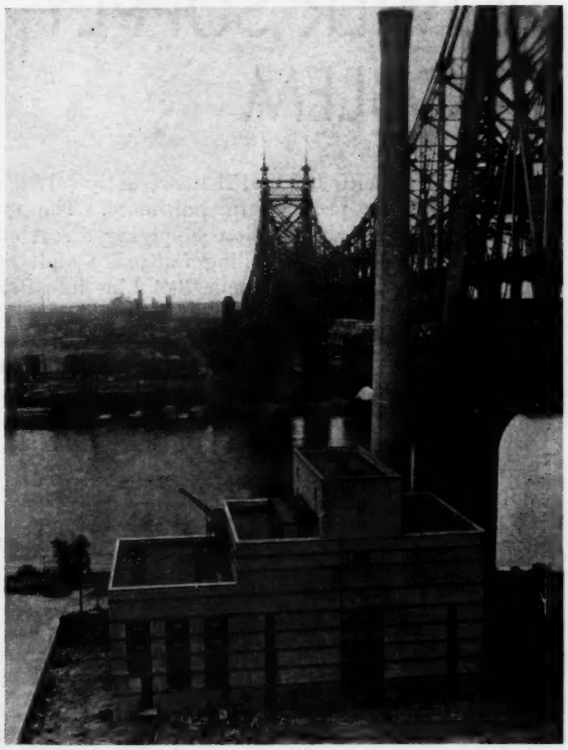
Mount Shasta, snow-capped, 14,161-ft. landmark of Northern California, from which the great 560-ft. storage dam, now under construction by the Bureau of Reclamation on the Sacramento River, takes its name. Melted snow from this peak is a principal source of the Sacramento River, a river which has deposited two-thirds of its flow into the Pacific. Shasta Dam will store this water, and that of the Pit, and McCloud rivers which flow into the Sacramento above the dam, for aid to navigation and flood control, and for irrigation and power

Shasta damsite on the Sacramento River, California. Here will be built by the Bureau of Reclamation a 560-ft. dam, second in height only to famed Boulder Dam, and in size more massive than Boulder but second to Grand Coulee Dam. This great conservation project of California's most precious natural resource, water, is being constructed at a point on the Sacramento River, just above the town of Redding, Calif.

# of Engineering Interest

Below is shown one of many developments built in various parts of the country by the aid of PWA funds. This is the new hydro-electric power house and surge tank of the North Platt development in Nebraska. Whatever criticism directed at these plants, and there has been plenty, certainly cannot involve the fine architectural handling of this structure. Its simplicity of line and skillful handling of the surge tank reflects a high degree of architectural and engineering skill





Another plant built by the aid of PWA funds. This is the new Welfare Island Power Plant recently completed in the city of New York

Turning a shaft as large as this is a slow, painstaking job. This is part of a large water-wheel generator being manufactured at the East Pittsburgh Works of the Westinghouse Electric & Mfg. Co. The shaft has a diameter of 36 in. at the end in foreground and is stepped to a minimum diameter of 28 in. at the other end. Cutting speeds are relatively slow. After a single roughing cut at about 35 ft. per min., a keyway 7½ in. wide, 61 in. long and about 3 in. deep is tooled in the shaft; then the finishing cut is made at 25 ft. per min.

RECTIFIERS SOLVE POWER SUPPLY PROBLEM

MERCURY-ARC RECTIFIERS recently solved an interesting problem in Baltimore. The synchronous converter substation supplying direct current to the locomotives pulling Baltimore and Ohio trains up the electrified 3.7 mile Belt Line into Baltimore, which includes the 1.4-mile Howard Street Tunnel, had to be moved to make way for a street extension. Railroad-owned space was available a few feet from the old substation, but it was directly over the tunnel itself, and it was felt that the tunnel walls were not strong enough to stand the vibration of the old rotating conversion equipment. To move the substation to other sites some distance away would involve considerable expense in rearranging alternating- and direct-current feeder cables, the purchase of another synchronous converter for use during the transition period, and the purchase of the land necessary.

All these difficulties were overcome by the use of rectifiers. Because foundation requirements for rectifiers are much less than for rotating machinery they could safely be placed in a new building directly over the tunnel. Cable rearrangements were held to a minimum, and service could be maintained by the old station until the rectifiers were ready for the load, and then the 28-year old converters retired. As a consequence, a new, much smaller, and less expensive building was built and two 3000-kw. sectionalized Westinghouse rectifiers were installed and placed in regular service.

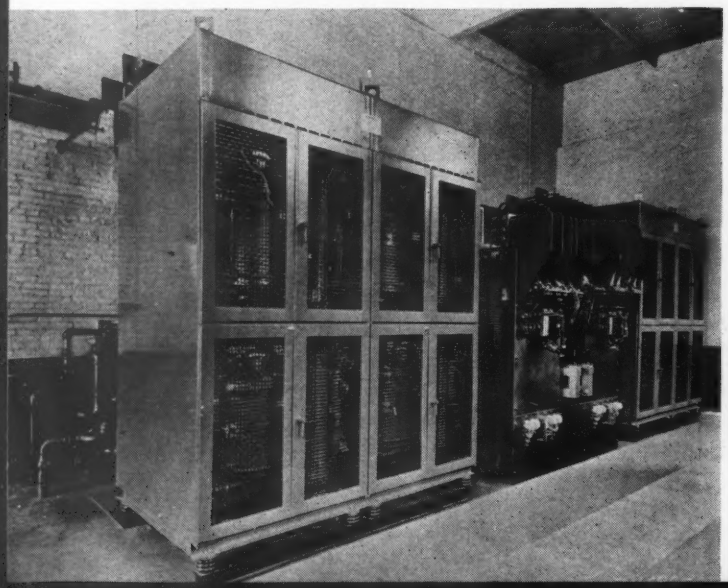
The most important requirement of the substation is that it supply 670 v. direct current to the tunnel feeders with absolutely no interruption. It is imperative that no train be stalled in the tunnel. To meet this high demand, two four-section rectifiers were chosen, each with sufficient overload capacity to carry the maximum load, which consists of two eastbound trains, one freight train hauled by four electric locomotives, and one passenger train requiring two locomotives. The rectifiers are each rated at 3000 kw., continuous, with 150 per cent load capacity for two hours, or 300 per cent load for five minutes. Supplying each rectifying unit is a water-cooled, three-phase rectifier transformer.

The switching equipment is housed in five metal-clad cabinets and includes two 25-kv-a, 13,200/220-110-v. transformers for the auxiliaries, two 600-amp., 15-kv. oil current breakers, potential transformers, current-limiting resistors and a breaker position used as a bus sectionalizing disconnecting switch. On the control panel are two graphic wattmeters, a direct-current voltmeter, two alternating-current kilovoltmeters, two ammeters, overcurrent relays, and two polyphase watt-hour meters. On a separate switchboard are mounted the direct-current air circuit breakers and knife switches. Behind this switchboard are two high-speed, water-cooled, direct-current circuit breakers rated at 10,000 amp., 250 v.

These new rectifiers show an appreciable saving in power over the converter station. Because there are frequent and long periods when no eastbound (upgrade) trains are in the tunnel, the rectifiers frequently are entirely unloaded—followed, perhaps instantly, by a heavy overload. For this reason no-load losses are important. The average no-load losses of one 3000-kw. rectifier are about 35 kw. less than for 3000 kw. of converter capacity (one 2000-and one 1000-kw. unit). This comparison, furthermore, is based on continuous operation of the heat exchanger for the second unit and other thermal devices and pumps which make it possible for the second rectifier to be placed in service simply by closing the ignition switch and the alternating-and direct-switches. Thus the spare capacity of the rectifier station is always instantly available whereas some time is required to get the additional converter equipment ready to carry load. Besides having a direct money value the lower losses of the rectifier station have an incidental advantage. The substation building in the summer is a much more comfortable place in which the attendants must work.

Space requirements of the rectifiers are much less than for the converter station In fact the figures for the three stations supplying power to the tunnel equipment throughout its electrified history give a striking picture of electrical progress. Space requirements for the electrical equipment of the original Belt Line power plant (built in 1894), for the converter substation (1910), and for the present rectifier substation are 68, 22.2, and 9.8 cubic feet per kw. capacity, respectively, or in terms of percentages 100, 32.7, and 14.5 per cent. The floor space required per kilowatt for the rectifiers is only 37.5 of that used by the converter plant.

In two and a half months of service the rectifiers have carried the Belt Line load successfully and without a single instance of backfire. The rectifier equipment is being operated by the same personnel that operated the old rotating conversion station. Only a short period of instruction was necessary for the men to learn the technique of operating the new and very much different equipment.



Installation view of the two 3000 kw. sectionalized Westinghouse rectifiers supplying d-c power for the electrified 3.7-mile Belt Line of the Baltimore and Ohio Railroad in Baltimore.

Errors in Reading Water Gages

Common Causes of Erroneous Water Level Indications in Boilers Under Operation

By C. C. CUSTER

IF YOU were to ask a number of engineers the question "Does the height of the water in the water column always indicate the true level of water in the boiler?" most of them would say "certainly it does, provided the column is not stopped up." There are a number of different cases, however, where there are no stoppages in the column or glass connections and yet where the height of water in the column may vary more or less from the actual level of water in the boiler. In such cases, the engineer may be misled as to the true condition of the water level unless he understands the conditions that bring about erroneous water glass readings.

Figure 1 shows a horizontal tubular boiler having the piping to the water column laid out so that the vertical distance of the piping above the gage is approximately equal to that below the gage; that is, BA is equal to AC. In this case the true level of the water in the boiler will be indicated in the glass. If however, the lip union in the steam line should spring a leak, a suction would be created at the top of the water column and the glass may show a gage or more of water above the actual level of water in the boiler.

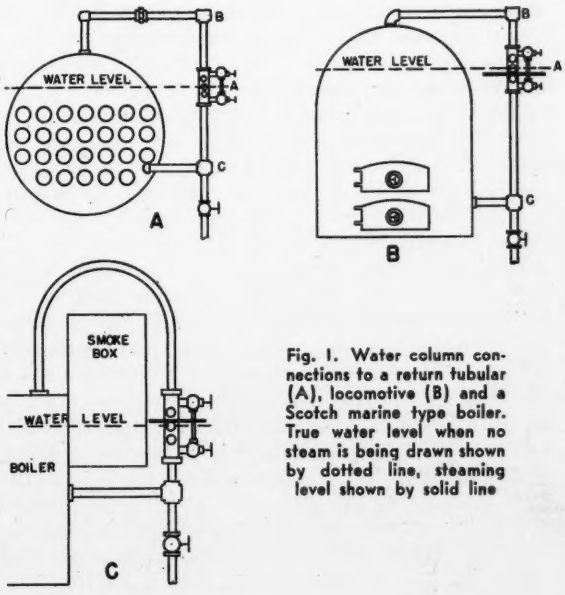


Fig. 1. Water column connections to a return tubular (A), locomotive (B) and a Scotch marine type boiler. True water level when no steam is being drawn shown by dotted line, steaming level shown by solid line

Cases similar to above may occur also, but not so pronounced, where there are slight traps in either the top or bottom piping to the water column.

Figure 1B shows a typical case of a locomotive fire box boiler where the distance AC is much greater than AB and the lower connection AC being long and consisting of bare pipe the water gets colder in the bottom connection and being of greater specific gravity it does not take so much of it to balance the height of water

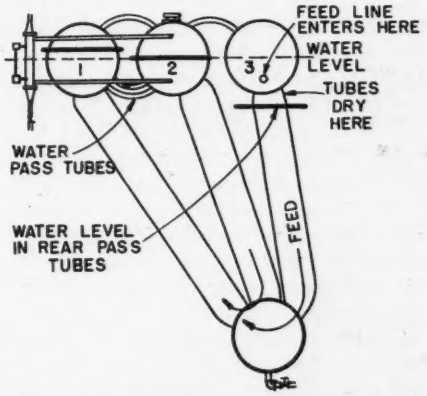


Fig. 2. Dotted line shows probable level in all three drums when no steam is being used; the solid lines show levels when boiler is steaming at rated capacity

inside the boiler. The gage will thus show an inch or so less water in the glass than the true level of water in the boiler. This can be proven by blowing down the column hard and long and thus let hotter water into the bottom pipe in which case the water level will probably be about an inch higher. In the sketch 1B the solid line shows the level as shown before blowing.

Figure 1C shows a common condition in the Scotch marine type of boiler where on the stokehold side of the boiler the uptake is in the way of the piping. Here an excessive amount of piping of the steam connection is used and condensation is great in these exposed pipes so that the water in glass may be as much as an inch above the true level in the boiler. I have had experience with a Scotch marine boiler of a boat where there was a water column in the fire room piped like Fig. 1C and another in the engine room side of boiler piped like Fig. 1B and neither one would be

correct, as they indicated about 2-in. different level, if given a hard blow down, however, they would show temporarily nearly the same thing.

Several cases have come to my attention where some engineer has tapped into the top connection of his water column line to get a steam supply for his injector. He soon abandoned this when he found that whenever he started the injector, the water level in the glass rose clear to the top of the glass so he did not know when to stop feeding with the injector. Then there was the engineer who took a tap out of the top of the water column to supply a small closed pocket type heater for hot water for a barber. Whenever the barber drew out hot water there would be a surge of steam to the heater that would create a false level of water in the gage glass. On account of such dangers as these arising, the A. S. M. E. Code states that the only permissible taps on the steam line of the top of water column shall be for either inserting a steam gage or a damper-regulator connection, as the steam taken by these devices is so small as not to affect the water level in the column.

Then there are a number of cases of erroneous gage indications that are the effect of steam and water circulation inside the boiler. Anyone who has watched water boiling in an open kettle will know that water as it boils has not a well defined level, as the parts where the steam bubbles are rapidly rising will produce higher water at these points. Take for instance the case of the old type Stirling boiler. The water column here was connected to the middle drum and the presumable water level is shown by the dotted line to be the same in all three steam drums. This was only approximately correct when no steam was taken from the boiler either by way of steam nozzle or by safety valve blowing. Whenever a great quantity of steam was being taken from the boiler the level in the front drum would rise on account of the first pass being hottest and the water in rear drum would recede, the true levels in each drum being as shown by the solid lines. The fluctuations of water level in rear drum would thus be quite extensive and the tube ends that enter this drum would some of the time be wet and sometimes dry and these changes of temperature would rapidly deteriorate the tubes at this point so they would show fire-cracks. With this type of boiler it was desirable that the boiler feed pump be kept running all the time so as to prevent too great fluctuation of water in rear drum. Later designs of Stirling boilers employ water pass tubes between the two rear drums.

A water tube boiler that I recently inspected had baffles over the uptakes from front water leg to steam drum in order to prevent the violent disengaging of steam from throwing water up into the dry-pipe and carrying moist steam over into the engine. The water column supply pipe was tapped into the drum just below this baffle. The baffle plates came loose and the engineer temporarily took them out till he could get a new supply of retaining bolts. He was surprised to find that with the baffles out the water column showed an unsteadiness not before noted and at times showed a false level on account of the rapid circulation of the water and steam inside the drum.

Another interesting case of variations of water level is the case of the locomotive boiler equipped with

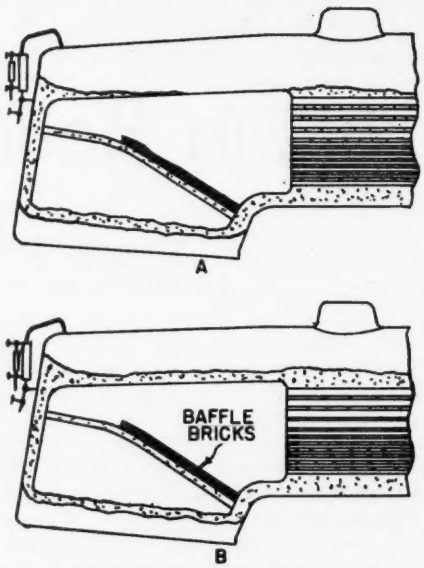


Fig. 3. Illustrating how water level indicators are affected by steaming characteristics

draft tubes and baffle-bricks as shown in Fig. 3. These draft tubes pour a stream of steam bubbles out into front shell close to the lower water column tap which causes the water to pile up near the front head when the boiler is violently steaming which shows plenty of water in glass, while in reality the crown sheet was dry as indicated in Fig. 3A. In order to have sufficient water on the crown sheet it would be necessary to carry the water gage nearly full as shown in Fig. 3B. If, however, the point of water supply to the water column were moved down lower or away from the point of discharge of the baffle tubes it was found by experiment that the water column indications were much more unvarying and reliable. U. S. Interstate Commerce inspectors have determined by experiment and observation through bull's-eyes fitted into the shell of a boiler that the water when the boiler is violently steaming often rises as much as 6 in. higher just above the side water leg of such a boiler so that a pet or try-cock tapped directly into the shell at the side of boiler may sometimes show 6 in. more of water in the boiler than does the water column.

These conditions may be easily proven in any case by shutting off the steam supplied by the boiler and waiting for the safety valve to cease blowing in which case if the water level indicating devices show a different reading than before, it is a proof that the former indications were in error. There are several other causes of erroneous water gage readings that might be mentioned. One case noted was of a horizontal return tubular boiler where the brick work near the lower column connection fell away allowing the flames to short circuit and impinge on the pipe, causing steam to be generated and escape upward to the column making the water in glass very unsteady. Also a foaming boiler creates a very erratic indication of water level in the glass with which most engineers are familiar. It is of course important that the engineer be posted on all these conditions that might affect the true recording of the safe water level.

Selecting Refrigerating Machine Lubricants*

CHEMICALS ADAPTED to refrigeration purposes have been popularized by the development of the air conditioning or comfort cooling industry and its counterpart—electric refrigeration. Some are practically inert; others in turn are miscible with petroleum lubricating oils; while still others seem to have little or no tendency towards reaction or solution with the latter. We were dealing with this third classification when ammonia and carbon dioxide were the predominating refrigerants.

Later as sulfur dioxide was applied to lower pressure units, the possibility of chemical reaction had to be anticipated, especially in the presence of moisture; this imposed the requirement of high dielectric strength in the lubricating oil, a feature which has come to be regarded as one of the most important characteristics today. More recently has the industry had to consider the viscosity-reducing effects of the chlorinated and fluorinated refrigerants, such as Carrene, methyl chloride and the "Freon" group.

All this has imposed a most exacting obligation upon the petroleum industry, to develop a type of lubricating oil which will resist these changes as much as possible. It has required intensive research, and most precise methods of refinement.

When it first became incumbent upon the oil industry to investigate the manufacture of lubricating oils for this type of refrigeration, the pour test was regarded as the salient characteristic, and refinery procedure was patterned accordingly. Later, it was developed that chemical stability, as measured by resistance to oxidation required even more careful consideration. So this became the primary objective in the manufacture of such oils; the several physical characteristics such as viscosity range, moisture content, pour and flash points are regarded chiefly as control factors to be developed in the course of refinement according to specific requirements of the machinery builders.

Moistures

At the same time it has been found necessary to take the utmost precautions to keep such oils free from moisture, as this latter, when the oil comes in contact with certain types of refrigerants, accelerates corrosion, to promote the formation of detrimental deposits or, even to enter directly into chemical reaction under certain conditions of pressure and temperature. Hence the adoption of a drastic dielectric strength requirement as part of the usual purchasing specification for refrigeration oils.

To offset the above where water cannot be entirely removed, some builders have added a small amount of alcohol as an anti-freeze, using the anhydrous methyl variety. Alcohol, however, can best be regarded as a remedy, not a cure. Furthermore, most alcohols are not anhydrous so careless action on the part of a service man may lead to introduction of sufficient water with the alcohol to subsequently cause serious deposits to develop. The presence of alcohol, even in its purest form, is also claimed to be objectionable, as it adds another chemical to the already complex assortment which is presented by the refrigerant, the lubricating oil and the usual metals employed in the system.

Moisture in refrigerating compressor service will be most likely to cause corrosion when sulfur dioxide is being used. Sludge or objectionable deposits will in turn be experienced with methyl chloride, Carrene and the "Freon" group.

The initial charges of refrigerant and oil, therefore, must be virtually water-free, and care must be taken to prevent the occurrence of leaks which might lead to entry of moisture-laden air and subsequent condensation of moisture.

Storage

Petroleum oils which have been actively dehydrated will tend to re-absorb a certain amount of moisture when exposed to the air for any length of time. This will result in reduction of their dielectric strength, dependent upon the relative humidity of the air, the temperature range and the length of time they have been so exposed. They should therefore be carefully stored and the containers opened only when it is necessary to use the oil; subsequently, if any oil remains unused the containers should be sealed as tightly as possible using special air-tight replaceable tops when cans are involved, or sealing gaskets on metal drums.

Before usage it is always advisable to keep containers of oil at room temperature, or the temperature of handling, for at least 24 hr. This will assure of an equalized temperature, and will reduce the possibility of moisture condensation in the oil and impairment of its dielectric strength. It is always perfectly feasible to bring back the dielectric strength by refiltration through specially dried blotting paper, but this is a costly procedure which careful handling of the oils should render unnecessary.

The tendency which mineral oils will have to mix or go into solution with the chlorinated or fluorinated refrigerants has fostered a decided interest in the subsequent viscosity of the mixtures. In the beginning it led to consideration of oils of somewhat heavier original viscosity than subsequent experience proved were necessary.

The resultant performance of the lighter viscosity

*From a paper prepared for The Texas Co., Lubrication.

refrigerating oils within say a range of 150 to 300 sec. Saybolt Universal at 100 deg. F., has been convincing. It was definitely indicated that they were capable of affording entirely dependable lubrication even though the viscosity of the lubricating film was materially reduced by the refrigerant. This has justified the use of such oils by a number of builders who even go so far as to apply the same oil to both "Freon" and sulfur dioxide units.

Air Separators

In the liquid phase, the above refrigerants are all entirely miscible with pertoleum oils. When these refrigerants are in the gaseous phase, however, the oil is almost entirely liquid; as such it absorbs only a small portion of the gas. In other words, the respective refrigerant vapors will go into solution less rapidly, all dependent upon the prevailing pressures and temperatures. Larger amounts of "Freon," methyl chloride and Carrene are absorbed by mineral oils at higher pressures and lower temperatures, just as smaller amounts will be absorbed at lower pressures and higher temperatures.

The separator is of value wherever an excess of oil might otherwise find its way to the evaporating or cooling side of a refrigerating system. Such a device is most effective where it is capable of removing particles of oil from the refrigerant while the latter is in gaseous form after it has left the compressor. The location of such a device is very important. In general it should be placed between the discharge of the compressor and the point of entry of the gas into the condenser, because the oil must be removed before the gas is liquefied. Where the oil fails to function properly, the reason is often because the separator is set too near the compressor, the rush of hot gas preventing proper condensation and collection of the oil.

Oil will be practically always atomized to a certain extent by virtue of the heat of compression which is prevalent. This oil mist will naturally tend to pass into the system with the refrigerant, to condense and remain in the colder parts, unless it is effectively removed, before it enters the condenser. In consequence, the separator should be set as close to the condenser and as far away from the compressor as possible.

Checking Performance

Where it is impossible to locate the main oil separator elsewhere than adjacent to the compressor, it is well to use an oil of as low an atomizing tendency as possible. This property will usually accompany high viscosity. The choice of a heavier oil would, therefore, solve the problem to some extent. In general, an oil of a viscosity of about 300 dec. Saybolt at 100 deg. F. will meet these conditions.

In compressors lubricated by controlled force feed the efficiency of an oil separator can often be checked by comparing the amount of oil removed from it with the amount fed to the compressor. Any extensive difference would indicate that the oil is not being entirely removed or trapped. Allowance, of course, should be made for oil leakage around the stuffing box, although to just what extent this may occur will depend upon the design of the individual installation, the care given to lubrication, the original viscosity of the oil and the means by which this oil is circulated or applied.

Modern Boiler Furnaces*

Furnaces serving modern boilers operated at high temperatures encounter ash and slag problems which vary with burning methods and kinds of fuel.

By E. G. BAILEY

Vice-President, Babcock & Wilcox Company.

ASH AND SLAG from the burning of coal have long been recognized as important factors in boiler-furnace operation. Hand-fired boilers were often limited in output by clinkers in the fuel bed, with resulting excess burden on the firemen. Certain kinds of stokers were ill-adapted to handling clinkering coals, while others were developed to cope with the same coal much better. Forced-draft stokers extended the clinker trouble, formerly restricted largely to the fuel bed, to the furnace walls and boiler tube banks, where "bird nesting" of slag was a serious trouble. Pulverized-coal firing, as first applied to slightly modified furnaces, did the same, but to a greater degree, as a higher percentage of ash was in suspension.

Water-cooled furnaces have overcome the erosion of the walls, and aided in lowering the temperature of the gases before entering the boiler tube bank. The spacing of the boiler tubes has been increased to minimize the tendency of ash and slag to accumulate. Turbulent pulverized-coal burners, resulting in more complete combustion with shorter gas travels and low excess air, have also been developed.

It seems that as soon as there are solutions for one set of conditions, new problems of economic importance arise which can only be solved by further study of the factors which enter the problem.

Some of the new problems of today are found in the design of steam-generating equipment for higher capacities which will produce steam at high pressures and at temperatures of from 900 to 950 deg. F. under

*Abstract of paper presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, N. Y., December 5-9, 1938.

close control, and which can be erected within restricted building spaces available. In fact, the steam temperature must be under accurate control because of the requirements of the turbine and the approach toward safe limits of tube temperatures at the high pressures. Superheaters must absorb more than 25 per cent of the total heat produced in the furnace, and to do this with any reasonable amount of surface they must receive gases at fairly high and dependable temperatures.

The greatest single difficulty to be overcome in accomplishing all of this is the ash in the coal being burned. Not so much ash as such, but ash converted into slag through high-temperature combusion; slag that is inevitable, even from the lowest possible combustion temperature when using many of the low-fusing-ash coals, which are available today. Ash constitutes the main problem; ash in the form of molten slag, plastic slag, sticky slag, sponge ash, and fly ash.

Dry ash removal from pulverized-coal-fired furnaces is satisfactorily accomplished with a wide range of ash-fusing temperatures, using turbulent burners, water-cooled furnaces, and rates of combustion from 25,000 to 35,000 B.t.u. per cu. ft. per hr. Such units are suitable for steam outputs up to about 200,000 lb. per hr. and for moderate steam temperatures. For larger units, the ash and slag limitations call for lower rates of liberation and/or higher fusing temperature of ash, and perhaps less-turbulent burners. In many localities there is available only a limited amount of coal of high ash-fusion temperature and therefore large furnaces for dry ash removal are being used less extensively.

The nature of the ash in the coal is of greatest importance in designing a furnace for dry ash removal. The intense heat resulting from turbulent burners causes temperatures sufficiently high to fuse almost any ash locally within the active-combustion zone. For satisfactory operation with dry ash removal, the places where the ash discharges to the ash pit, and the gases to the tube bank, must be far enough away from the burner zone to permit the necessary cooling of the ash before leaving the furnace, or else it will adhere to the hopper or other cooling means at the bottom, and to the boiler tubes at the top. In any event, some ash will adhere to waterwalls of any known construction, around the middle of the furnace within the burner zone, as shown diagrammatically in Fig. 1.

If mechanical cleaning is applied to this area, and it is kept reasonably clean, the furnace may be too cold for stable ignition and efficient combustion, especially at lower rates. The rate of radiant-heat absorption may also be too high for the safety of the tubes, if the water conditions are not perfect. Experiences with gas- and oil-fired boilers bear out these points, and some protection of bare water-cooled walls is necessary to obtain complete combustion and protect the walls against tube losses.

With coal firing, the ash or slag accumulation in this zone is uncertain, and troublesome because of its uncertainty. With a combination of ash characteristics and rate of combustion which produce a sticky but not liquid ash formation on the walls, the thickness of sponge ash may increase and spread both up and down to greater areas, insulating the heat-absorptive surface so that gas temperatures rise. Higher gas temperatures further accentuate the spreading and thickening until unduly

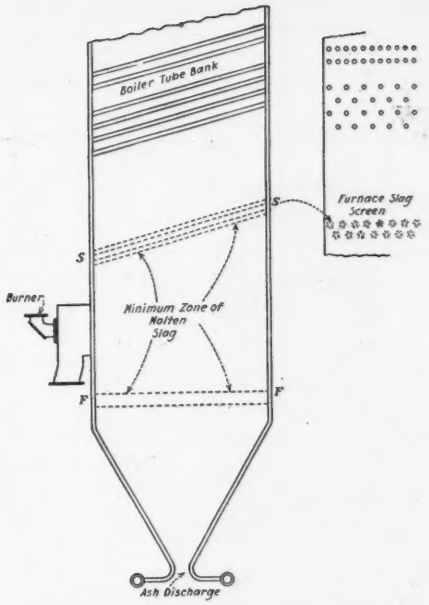


Fig. 1. Diagram of typical modern furnace

high temperatures reach the boiler tube bank and the bottom of the ash discharge and cause slagging troubles in one or both of these locations. Thick accumulations of slag, sometimes quite bulky, may fall intermittently from the upper part of the furnace, causing damage to the furnace structure.

If the ash characteristics and temperature to which it is subjected are such that the slag is of a molten plastic nature, the covered area will also spread downward and upward, necessitating some cleaning to keep the coated area within bounds and also cleaning of the tube bank and ash discharge openings.

Another approach to the problem is to make the furnace of Fig. 1 with a floor at *FF*, which will accumulate molten slag, and to tap it out continuously or intermittently. This raises the furnace temperature in this zone so that the ash on the walls melts and thins down to an equilibrium thickness, with the net result that a higher rate of heat absorption per square foot of the lessened area takes place than existed in this zone before the floor was installed. The temperature in the slag zone is high enough to cause extending of the slag coating upward toward the boiler tube bank. This may call for cleaning of the walls in the upper part of the furnace, as the tube bank would otherwise have to be at an unreasonable height to prevent a gradual extension of slag, which would further insulate the wall and increase the gas temperature as the slag coating extended upward into the tube bank.

As radiant heat from the hot burner zone reaching the upper part of the furnace and boiler tube bank contributes to keeping the slag particles hotter than they would be if shielded, it is obvious that the placing of a screen *SS*, shown as consisting of water tubes coated with a slag-resisting refractory held on to the tubes by a suitable means, across the upper part of the furnace, making a two-stage furnace, serves a useful purpose. (1) The arch effect further increases the temperature of the combustion zone in the primary furnace, which increases the rate of heat absorption per square foot of

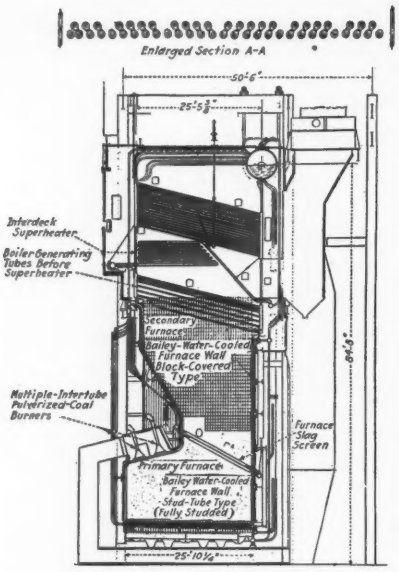


Fig. 2. Boiler with two-stage furnace

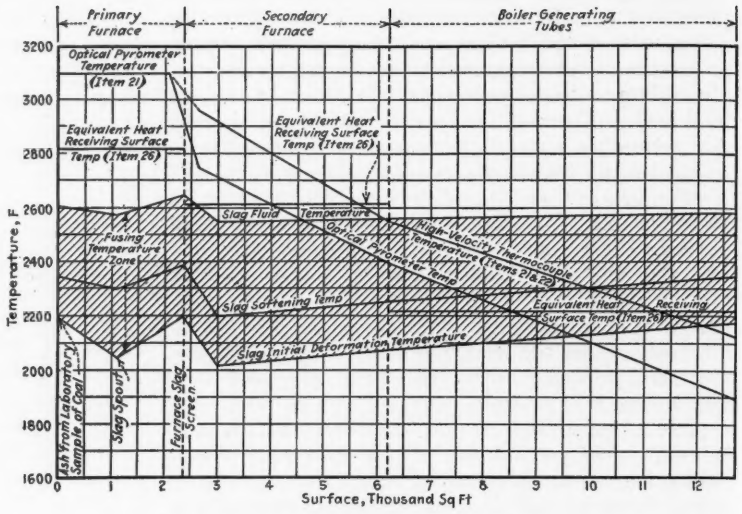


Fig. 3. Gas-ash temperature graph for unit shown in Fig. 2

remaining wall area and makes tapping of slag possible for higher-fusing-temperature ash, and for lower rates of combustion with a given ash. (2) The temperatures of ash and slag above the screen are reduced. (3) Any cleaning of the walls or boiler tube bank in the upper or secondary furnace is more effectively done in this cooler zone, and there is a more definite zone within which cleaning is possible. The screen cleans itself by the melting of the ash, which drips back into the primary furnace. (4) a larger percentage of the ash of the coal is collected than is recovered in a furnace for dry ash removal.

Test Results

The nature and behavior of the ash and slag have also been observed during operation, samples have been taken of ash from the coal being burned, and samples of slag and the different kinds of ash from various parts of the furnace, slag screens, and tube banks. The fusing-temperature ranges of these samples have been determined with a view to learning whether or not the ash and slag samples, and their behavior at known temperatures in the laboratory would add to the knowledge of actual temperatures in different zones of a furnace.

While it is well recognized that ash in coal is a complex substance and individual constituents of it vary in fusing temperature from as low as 1800 deg. F. to as high as 4000 deg. F., it is treated as a mixture; in the laboratory, ash residue from a slowly burned out coal sample is formed into a cone-shaped briquet and its fusing-temperature range is determined in a muffle furnace and reported as (1) initial-deformation temperature, (2) softening temperature, and (3) fluid temperature. The initial deformation is that at which the cone starts to distort and is really indicative of when the lowest-fusing-temperature particles begin to soften and cement the high-fusing particles. The softening temperature is that at which the cone has softened enough to turn the apex downward, or to bend the axis about 90 deg. from its initial vertical position. This particular temperature has been referred to in the past as the fusing temperature and has been generally used as the important temperature in measuring the behavior of the ash and comparing the relative values of coal. When coal is to be burned in fuel beds this temperature is of value for comparisons, but it is now believed to be of little significance in large pulverized-coal-fired furnaces. The fluid or liquid temperature is important in connection with slag-tap furnaces and for a knowledge of the behavior of ash in water-cooled furnaces operating at temperatures above the fluid or liquid temperature of the ash, as most of them do at their normal and maximum ratings.

Within a furnace or boiler unit, the ash collecting at any point may not be a true average of all that which is in the coal. Dense, hard-grinding particles, such as sulphide from pyrites, are more likely to be retained on the floor of a furnace. High-fusing-temperature particles are more likely to pass on through the entire furnace and boiler unit as fly ash, as they themselves are not sticky but they may be retained to some degree by adhering to sticky ash already retained on the surfaces. The particles which are molten have a double chance of being retained within the furnace, due to their sticking to cold surfaces, and surely to hot sticky surfaces.

The superheater bank, usually consisting of relatively closely spaced small tubes, must be kept clean. This means that the fly ash should be below its sticky temperature, yet the gases should be as hot as possible for high superheat. The velocity and temperature of gases should be as uniform as possible to all parts of the entering area of the superheater for the protection of the tubes. Some cleaning device is needed, as a gradual accumulation of sponge ash or dust is inevitable. It should be kept uniformly clean, because if certain areas accumulate sponge ash and direct the flow of gases to limited portions of the superheater the higher gas-mass flow may quickly overheat such portions of the superheater tubes.

Gleanings From a Lifetime of Experience

Opinions based on many years of hard work and close observation of men and machines in the power field.

By H. A. CRANFORD

THIRTY YEARS as an engineer specializing in power and refrigeration has taught me:

That there are very few ice and cold storage plants in which the horsepower demand and kilowatt-hour consumption could not be lowered, from 10 to 50 per cent, if the engineer knew the relation of temperatures to pressures. This knowledge, combined with the use of thermometers and the Bureau of Standards ammonia tables, would enable the engineer to solve his operating problems intelligently, keep his plant in perfect balance and at high efficiency.

That nearly all engineers, when the demand for ice drops to half capacity, stop the plant at night and run during the day. Would it not be more logical to run at night and shut down in the hottest part of the 24 hr., that is, during the day? Night temperatures are much lower, and I never saw a plant of any kind that did not run better at night than during the day. Why, I do not know, but I have heard many an engineer comment on the fact that any kind of machinery works better at night than during the day hours.

That 90 per cent of cracked or shattered ice is caused by the incorrect pH factor of the water. In most cases the condition can be corrected by simple water treatment with inexpensive equipment. Also, that very few operating engineers in plants of 50 t. or less know what you are talking about when you mention "pH" and seem to care less. Not one in 20 knows how to test brine or water for acidity or alkalinity.

That in checking numerous plants from Canada to the Gulf of Mexico, on an average, only one plant in eight, had correct brine. Either low specific gravity, high acidity or high alkalinity.

That strong drink has ruined more good engineers than all other causes combined. And it seems to be the brilliant ones that it gets. The plodders seem never to be drinkers. Nowadays, even the odor of whiskey or beer on a man's breath, constitutes drunkenness in the eyes of many employers. And although little attention is paid to the general run of employes drinking, the employer resents it if his engineer takes even a social drink. Too much depends on his mind being alert and clear.

That I never knew of an engineer being discharged for any cause but drunkenness or dishonesty that didn't come back with a better job than the one from which he was discharged.

That a large proportion of smaller industrial plants, especially refrigeration plants, are located and built without any thought being given to an adequate and economical water supply. And often little consideration is given as to whether the water is suitable for the use it is to be put to. It strikes me as being strange that this is the case, when water is one of, if not the most important, item entering into the economical operation of many types of plants.

Plant Upkeep

That few engineers have the ability to explain needed repairs and improvements, costs and resulting savings to their employers. They seem to be unable to put their engineering terms into language that their superiors can understand. One may rank high as an engineer, but unless he learns to talk the language that his employer talks, he will find himself handicapped. What the boss wants to know is "What will it cost," "What will it save," "How much will it increase capacity," and he wants the answer in plain, proven figures, in plain understandable language, with technical stuff left out. Class A or B or C contracts, as well as horsepower demand and kilowatt consumption mean little to him. It's dollars and cents, profit and loss, and will the increased plant efficiency justify the investment that he is interested in.

That in many plants, periodically, all machinery with moving parts, such as motors, engines, pumps and compressors are thoroughly overhauled. Large sums are spent putting them in apple pie order. But the boiler room often is sadly neglected. Sometimes they are cleaned out, furnace chipped and patched, and the front given a coat of cheap paint. Nowadays, with stokers adaptable to any boiler, at very low cost, with proper draft and feedwater control and tight boiler settings, the expense of operating boilers can be reduced far lower than the average engineer dreams possible. One specific instance was observed recently. An absorption ice plant, 50 t. ice making capacity was operating a 135-hp. water tube boiler. They were burning 7 to 8 t. of coal a day at $5.00 per ton delivered at the boiler front. A popular make of stoker was installed. The top of the boiler was covered with ½ in. asbestos cement, plastered on smoothly. On top of this, bricks were placed edgewise. Over the brick a ¾-in. thick layer of asbestos was plastered on. Side walls were tested for air leaks, and cracks filled with plastic refractory. A coat of asbestos ¾ in. thick, reinforced with poultry netting was plastered on smoothly over all exposed brick work. All tube headers were packed with asbestos rope and asbestos cement. The same around the cross drum ends. Baffles were gone over and repaired. Flue blowers installed and blowoff valves repaired. This work cost $2000. The plant is now burning only 5 t. of coal costing $4.75 per ton delivered to stoker. The plant is up to capacity because of the absolutely steady steam pressure which varies less than 5 lb. and is actually producing 10 t. of ice for each ton of coal consumed, or a fuel cost of $0.47½ per ton of ice. The plant is 17 yr. old. It is easily seen that these improvements will pay for themselves in less than 12 months and

pay a handsome dividend when the increase in production is figured. You may say that this is an exceptional case. But there are very few small or medium size plants that the fuel cost could not be reduced 25 per cent or more.

That poor boiler settings, dirty boilers, improper firing and bad draft control in steam plants, and air and oil in refrigeration plants, have cost plant owners millions of dollars. In refrigeration plants, next to oil and air, comes dirty condensers, low suction pressures, and dirty, weak brine. A 4-lb. suction pressure corresponds to minus 20 deg. temperature, and, theoretically, requires 1.1 hp. per ton refrigeration. 16 lb. suction pressure corresponds to zero temperature, and requires about 0.8 hp. Consequently it can be seen that for every increase in suction pressure there is a 2.5 per cent lowered power cost.

Packing Expedient

That in many of the old ammonia compessors there was an expansion valve for expanding some liquid ammonia into the suction line. The primary object seems to have been to keep the rod and packing from heating. I have found that the best thing to do is to disconnect this liquid line and plug the openings so it cannot possibly be used. If the gas is brought back to the machine at correct temperatures and pressures, the rod and packing will take care of themselves if properly adjusted.

That carrying temperatures of brine tanks and storage rooms lower than necessary costs money. Carry the temperatures no lower than necessary. The greater the difference between brine or room temperatures and the outside temperature, the greater will be the refrigeration loss, or loss of B.t.u.'s when ice is being harvested or the room doors are being opened, not counting the loss through walls and insulation. Much saving in power will result in close attention to required temperatures.

Fundamentals Are Important

That a lot of operating engineers cannot define the meaning of the terms saturated steam, superheated steam, wet gas, dry saturated gas, and dry superheated gas.

That if a better knowledge of the relation of condenser to power costs existed among engineers, it would result in immense savings, especially in the smaller plants. I think I am safe in saying, roughly speaking, that when the temperature on condenser is lowered 2 deg. the head pressure will drop 6 lb. and the power cost will be lowered about 3 per cent. It takes approximately about twice the power to produce 1 t. of refrigeration at 200 lb. head pressure that it would take if the head pressure were 100 lb. The other pressures are more or less proportional, and the figures above are used to bring home the importance of keeping the condenser clean, free of foreign gases and supplied with plenty of the coldest water available.

That too little attention is given to the cooling water for ammonia condensers. There should always be 7 to 10 deg. difference between the water to, and from, the condenser. Where this difference does not exist, there is something wrong. If the difference is less, the chances are the condenser needs cleaning. If the difference is greater, the chances are that there isn't enough water going over the condenser, or it is not being correctly distributed. But whatever the trouble, it should be located and corrected. The condenser is one of the first parts of the system that should be checked when trying to increase capacity or lower power costs.

Keep Accurate Record

That an accurate record of every pint of oil that is put into the compressor, should be kept faithfully. And when oil is drawn from the system, the ammonia should be evaporated from it by slightly heating it, and when it is about the same temperature as the oil that is put into the compressor, it should be carefully measured. Only in this manner can an engineer know positively that he is keeping the system free of oil. Oil is an insulator to a large degree, occupies space that should be occupied by ammonia, traps itself in low points in the system and retards the free circulation of the refrigerant. In short, a few gallons of oil in the system can cut down the capacity and increase the power costs an astonishing amount.

Shaft Removed by Heating and Cooling

Removal of a generator shaft from its spider was accomplished at Queenston, Ontario, station by a combined heating of the spider and cooling of the hollow shaft. Because of the field coils, heating of the spider arms was limited to 85 deg. C. (185 deg. F.) and was accomplished by means of charcoal heaters, over a period of 5 days, up to 176 deg. F. Meantime 25 gal. per min. of water at 39.5 deg. was run through the shaft to cool it. Temperature difference of 99 deg. F. was calculated as necessary to free the shaft from the shrink fit, as the shaft diameter of 32¼ in. was 0.009 in. larger than the bore of the spider. The spider fit on the shaft was in three steps with total length of 5 ft.

With spider laminations heated to 183.5 deg. F., the hub was at 122 deg. F. and the shaft was then at 82.5 deg. F. The difference, 40 deg., was not sufficient to free the shaft. Alcohol at 43 deg. was then circulated through the shaft at 200 gal. per min. and when ½ t. of dry ice was placed in the alcohol tank, temperature of the liquid dropped to –97.6 deg. F. in ½ hr. After 1 hr. the shaft moved under 200-t. pressure of hydraulic jacks and removal was completed by the end of another hour. Temperature difference between hub and shaft was about 61 deg. F. when movement started and about 83 deg. at completion.

During the operation, the rotor was mounted over a hatchway with the shaft, which was 30 ft. 3 in. long, vertical; the spider was housed in an insulated chamber which was heated by electric heaters, taking 55 kw. The special charcoal heaters used could supply 13,000 B.t.u. per hr. per sq. ft. of contact with the spider arms. Temperatures of rotor shaft and cooling liquid were measured by thirty-two thermocouples at key positions. It was estimated that at the end of the operation, the shaft diameter had been shrunk 0.018 in. so that it was 0.009 in. smaller than the bore of the hub.

Readers' Conference

These pages are open to readers for the presentation or discussion of any timely power plant topic. The Editors invite your participation.

Engineers' Licenses

I HEARTILY agree with Mr. Harvey's article in the December issue of POWER PLANT ENGINEERING in regard to educating and licensing boiler plant operators and engineers, but the motives behind numerous organizations sponsoring such movements are not always conducive to that end, in that their main objective is to create vacancies which they hope to fill by unemployed members of their societies or organizations through the aid of licensing laws. When employing boiler operators, I believe it would be wise to select the man who possessed some practical experience, who was level-headed and dependable, and who was endowed with enough brains to realize the dangers involved in attempting to operate boilers and sleep at the same time, rather than to select the man who had the ability to memorize a few questions and answers and perhaps obtain an operator's license.

It is a generally accepted fact that nearly all of the large industrial plants maintain a program of educational training for their worthy employees which is either carried out in the respective plants or through trade schools. There are any number of plants in this locality that pay tuition fees or a part thereof for employees to attend one of the several trade schools or universities in Cincinnati and which is of course beneficial to both the employee and employer.

Newport, Ky. HARRY H. RUTHERFORD, JR.

Waste

IT IS my belief that the greatest amount of waste takes place in small and medium size industrial power plants. Due to their construction, selection and arranging of power producing and power using equipment. In many cases much money and trouble could be saved by installing the proper equipment for the particular work to be done, instead of using some makeshift arrangement. Most industrial plants regard the power plant as a necessary evil, therefore it is usually the last department to be improved or modernized.

It is not uncommon to walk into an industrial plant and see the latest type of machinery producing the finished product while the power plant consists of old inefficient equipment. Of course in some cases it would be a doubtful move to install expensive heat saving equipment, but in most cases a considerable sum of money could be saved annually by spending a few dollars for improvements.

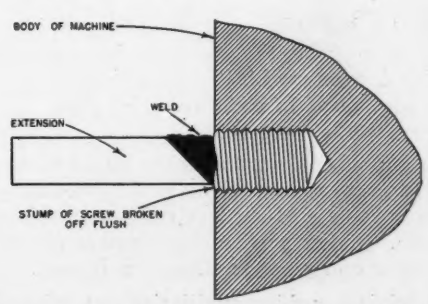
In one plant consisting of a 200-hp. boiler, steam was used for heat, to operate a small engine, and to operate two dryers and air lift pumping system. Ordinarily an air lift system gives good results, but in this case it was one of the most expensive pumping systems that I have ever seen. Air was supplied by two locomotive air brake compressors. Air brake compressors were designed for intermittent operation on locomotives, not for continuous stationary operation. No provisions were made for cooling the compressor cylinder. To make matters worse, the air line to the well was reduced from 1½ to ½ in. How a half inch air line was to displace the necessary amount of water I don't know. The exhaust steam from the compressors was discharged into the atmosphere, although a feedwater heater was nearby.

The condensate from the dryers was discharged into the atmosphere along with a large amount of live hot steam, as no traps were used. After fitting traps to the dryer coils and installing an automatic return system and by replacing the air lift system with a deep-well turbine pump with an electric drive, the coal consumption dropped from 40 t. per week to 20 t. At the present time the load is over twice as heavy as it was then.

South Vineland, N. J. TARQUIN DE ROSA.

Removing Broken Stud

ON A piece of heavy machinery we had the misfortune to break a ⅞-in. cap bolt, flush with the surface, and in such a position that the ordinary methods of removing the broken end were of no avail, since there was not room enough to drill the stub and then back it out. In order to replace this bolt it seemed as if it would be necessary to dis-assemble almost the entire machine, until we struck upon the expedient of arc-welding an extension to the stub, thus furnishing a means of turning it.



An extension arc welded to a broken stud, making possible its removal

The extension to be welded to the screw stub should be cut away on one end to an angle of 45 deg. or more, leaving only a point contact to meet the stud-face. When the parts are held together, this will give the welder a chance to start at the base of the V and build up a solid weld, much stronger and far easier to make than any attempt to weld around the entire circumference of the extension. Indeed, the last method would probably prove a dismal failure.

Care must be taken to prevent the weld from extending across the face of the stub and fusing the stub, extension and casting into one mass. If in one or two places a small rib does tack itself to the iron, these must be chipped free before attempting to turn the stub.

When ready apply pressure steadily to the wrench, and if room permits, strike upon the top of the extension with a hammer at the same time. A rusted or corroded stub should be well treated with some penetrative oil before attempting the actual removal.

West Warwick, R. I. JAMES P. MARSHALL.

Reflections

AFTER WORKING more than 32 yr. in a large power station, 22 of them as a watch engineer, I am now retiring from active service with the realization that I have served through the most eventful years in the history of the generation of electric current.

In the early 1900's the steam turbine was just beginning to take its proper place as a prime mover in the field of electric generation and its increase in size and speed of rotation was so rapid as to startle those who had seen few changes in the reciprocating engine in many years.

The station in which I have spent the best years of my life offers a good illustration of the rapidity with which those changes took place.

This station began operating late in the summer of 1905 with three 5500-kw., 3-phase, 25-cycle, 11,000-v. generators coupled to single flow reaction turbines equipped with poppet type steam admission valves. These machines were the wonder of their day and visitors came long distances to see them.

Five years later (1910) they were out of date for two more generators of 8000 kw. capacity and the same electrical characteristics as the others were added to the plant at that time. These were driven by semi-double flow impulse and reaction turbines equipped with hydraulically operated admission valves.

In 1914 a 20,000-kw. unit was added which ran at 1500 r.p.m. or twice the speed of the original units. From this date onward it became necessary to remove our old equipment to make room for new.

In 1923, 18 yr. after the plant began operating all of the original turbines, one of the 8000-kw. machines and all of the original turbine auxiliaries and surface condensers had gone their way to junk yard or second hand man. A few small duplex pumps are all that remain of the original auxiliary equipment.

The original turbine auxiliaries had, with the exception of the condensate pumps, been driven by reciprocating engines and these were replaced by turbine or motor drive. Some of the vacuum pumps have in recent years given way to air ejectors.

In the original layout of our auxiliary room the designers had been so confident that there would be little change in turbines and auxiliaries for years to come that they had extended some of the piping headers far down into the empty portion of the plant to provide for extensions. Alas for their confidence, it all had to be ripped out when extensions did come.

We made very few great changes in our boiler rooms. We removed the gravity overfeed stokers and replaced them with underfeeds and increased the furnace volume of our boilers. Our old reciprocating duplex feed pumps were replaced with motor and turbine driven centrifugals.

The rapid advance in turbine design had forced us to rebulid completely our turbine and auxiliary room equipment and many plants during these eventful years have gone even further and rebuilt their boilers as well.

In order to keep track of what has been going on in other power stations during this period I have had to depend on visits to nearby plants, but more particularly have I had to rely on good technical papers such as POWER PLANT ENGINEERING. It is impossible for any power plant man to keep fully informed of the developments in his field unless he takes at least one good technical paper and I would advise taking more than one. The information contained in them can be relied upon as being accurate.

As I step from the stage I feel that I have had a rich experience. The privilege of associating with intelligent men and learning from them how to solve the perplexing problems that are part and parcel of power plant operating is something to be highly treasured in the years to come. I now leave to others the task of carrying on a business that calls for skill, good judgment, courage to face difficulties and a high order of intelligence.

Richmond Hill, N. Y. JOHN TOOKER.

Hard Hats for Furnace Inspecting

FOR FURNACE repairs and inspecting or for any job with limited head room the wearing of hard hats or suitable protective head gear will prevent a lot of avoidable head injuries. Head injuries on these jobs are often only of a minor nature due to material falling from a small height or to movement of the head. A hard hat will destroy the force of the blow.

Also care should be taken when entering any furnace which has used any form of gas as a fuel. There may have been leakage from the gas main which has permitted gases to collect. The safest way is, before entering, to deliver compressed air from a suitable hose so that the whole space is thoroughly ventilated with air. Air can be delivered the whole time men are working or if desired can be adjusted by themselves.

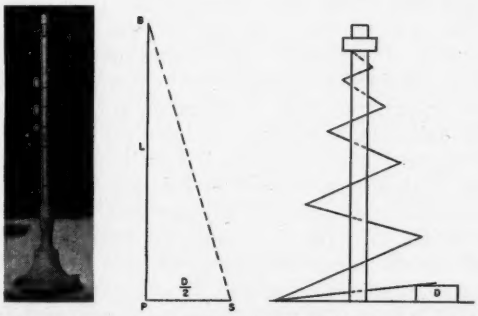
London, England. W. E. WARNER.

Guide Wear Traced to Valve Spring Shims

WHEN an internal combustion engine valve spring begins to weaken, as evidenced by slap or fluttering of the valve under light loads, the first thing many engineers do is to reach for a convenient shim and wedge it between the base of the spring and the cradle in which it rests. And, because the aggravating slap instantly ceases, the remedy gets the credit.

Checking a battery of 400-hp. gas engines for excessive guide replacement recently, it was found that (1) the springs were old and had never been tested for tension (there was even no record of correct or factory-specified tension); (2) wedges averaging 3/8 in. thickness had been used under one side only of the weakened valve springs; (3) kerosene had been used to accelerate spring action of closing of the valves after wedging.

Since the placing of a wedge under one side of a spring shortens the spring by that much, it increases the force exerted by that side of a coiled spring over that put out by the side remaining at original length. That this force can and does amount to a serious side



Photograph of the neck of a stem (left) eroded just above the valve to less than half the former size through slow closing caused by drag against the guide from off-center spring thrust. Valve spring with improper shim (right) under one side and (center) force diagram for determining amount of side pressure imposed on valve guide by shimmed spring

pressure against the top of the valve guide may be understood by the force diagram shown to the left of the spring sketched with a 3/8 in. wedge or block D under one side.

To prevent rotation about the point P of the sketch, it is evident that the equation

$$L \times B = \frac{D}{2} \times S$$

where L equals the height of spring, $\frac{D}{2}$ the radius of spring at point where wedge is applied, S is the unbalanced force set up by shortening one side of the spring, and B is the force required to maintain equilibrium; or, in other words, the push sustained by the guide. With a 100 lb. spring, a wedge 3/8 in. thick, the unbalanced force is 37.5 lb., when, with an 8-in. coil, 5 in. in diam., we have

$$B = \frac{37.5 \times 2.5}{8} = 11.72 \text{ lb.}$$

with valve closed, and 12.5 lb. when the distance L is shortened to 7.5 in., by the cam when the valve is full open.

This unbalanced force of over 11 lb., acting against the top of the guide during the half-inch reciprocating motion of the valve stem resulted in severe wear at this point, with eventual misalinement of the valve and seat, with erratic action, blow-by, and erosion of valves stems.

Valve springs being considered by the management as permanent parts of the engines, no spares were on hand, and so shims had to be used pending receipt of replacements. These shims were in the form of collars interposed between the top of the valve and the locking collar provided in original equipment. Where this type of take-up cannot readily be used, shimming at the base is permissible. Provided: that the shims or adjusting blocks be of equal height, and that they support at least two-thirds of the bottom or lower coil of the spring.

Apart from the misalinement caused by the wedges at one side, a fulcrum is thus provided which encourages bending at this point, with concentrated loading and eventual crystalization at the node thus formed. The life of a spring abused in this manner is seriously shortened, and engine breakdown more likely.

Longview, Texas — ELTON STERRETT.

Why Unscheduled Boiler Outage

VERY LITTLE has been written concerning the operating and maintenance troubles of modern industrial steam generating units. Regardless of the reasons behind this reticence, it is unfortunate that the operators of every new installation are compelled to learn the hard way and must experience and overcome difficulties that have already been encountered and solved in numerous other plants. Much of this unnecessary duplication of effort could have been avoided in the past and can be prevented from occurring in the future, if, when troubles do come up, details of their causes and cures are early made available in publications read by large numbers of men in the operating field. With this thought in mind, the following discussions of some of the happenings responsible for unscheduled boiler outage in a large industrial power plant has been prepared for the edification of the operating fraternity.

Each of the three steam generating units making up this particular installation has a capacity of 120,000 lb. of steam an hour at 450 lb. ga. pressure and 700 deg. F. total temperature and include 8500 sq. ft. of boiler and superheater surface, a 1500 sq. ft. nonsteaming return bend economizer, 980 sq. ft. of bare tube furnace water cooling surface and a 2500 sq. ft. tubular type air preheater. Furnaces are fired with

pulverized coal from a storage system through horizontal burners located in the front wall and have water screened dry bottoms. Auxiliary equipment includes variable speed motor driven forced and induced draft fans, hydraulic ash sluicing system, feedwater regulation, and a comprehensive instrument layout. These units have been in operation 8 yr. and during this period have either been in steaming or steaming standby service 80 per cent of the time and have had an average availability for steaming of well over 90 per cent.

Normally these boilers are removed from service for internal inspection and to perform needed maintenance after 3000 hr. on the line. In a number of instances, however, it has been necessary to remove a unit from service before its scheduled time in order to rectify some unforeseen wasteful or dangerous condition. Among the sources of this type of outage, together with the steps taken to prevent its recurrence are:

1. Leaking gaskets in the flanged joints of main and auxiliary steam piping. This trouble was rectified by substituting corrugated metal gaskets suited to the temperature and pressure for the asbestos sheet packing gasket rings originally installed. Since making this change piping joint trouble has been practically non-existent.

2. Leaks through sand holes and like imperfections in the metal of valves and fittings. Leakage of this type was especially troublesome immediately after the units were initially placed in service, and was taken care of in some cases by substituting new parts, in others by chipping out defective metal and then building up with a welding outfit.

3. Bulged furnace water cooling tube. When the unit affected was shut down so that this tube could be replaced an investigation revealed that an accumulation of sand had completely choked off all circulation through the damaged section, resulting in overheating of the metal.

4. Baffle troubles. During light load periods first pass baffles of all units were occasionally knocked down by minor furnace explosions or puffs that almost invariably occurred during the soot blowing operation. This trouble was partially eliminated by reducing the steam pressure on the first pass soot blower elements whenever load on the boilers dropped below a certain point so that unburned carbon on tubes and baffle was swept away gradually rather than in an explosive mass. Continued baffle difficulties confined to one of the three furnaces were finally discovered to be caused by an error in applying the soot blowing equipment; the elements were turning in the opposite direction from those in the other two settings. After correcting this condition the only baffle trouble experienced was an occasional tile knocked down by puffs resulting from improper furnace operation.

5. Leaking blowoff valves. Eliminated by hard surfacing seats and discs with stellite.

6. Leaking main steam supply valves of soot blower systems. Corrected with new seats and discs of the proper hardness supplied by the valve manufacturer.

7. Leaks around rivets and calking of auxiliary feed nozzle of one boiler. This trouble, the result of water hammer in the boiler feedwater piping system set up by the sudden breaking loose of a sticking pressure regulator on the discharge side of a motor driven boiler feed pump, and complicated by improper maintenance of pipeline anchors and hangers, was repaired by welding under supervision of the boiler manufacturer's representative.

8. Bent furnace ash pit screen tubes. These tubes were so seriously bowed by the fall of a weighty slag accumulation from the top of one furnace that replacement was necessary. Future accidents of this nature have been avoided by changing to a coal having less tendency to slag and controlling slag formations by daily hand lancing.

9. Leaking hand hole plate gaskets in the headers of furnace water cooling and ash pit screening tubes. Initially a frequent source of outage, this trouble has been taken care of by renewing all gaskets at predetermined intervals instead of depending upon the personal judgment of members of the maintenance crew as to suitability of a particular gasket for continued service.

10. Burned out superheater tubes. After 7 yr. service two superheater tubes of one unit failed due to overheating, necessitating renewal of both these and several adjacent boiler tubes cut by escaping steam. Solid deposits left by evaporation of boiler water carryover were responsible for this trouble. Although a steam purifier was installed between boiler outlet and the superheater, it was inoperative at the time, having been cut out several years before when exhaustive tests revealed no appreciable carryover in the steam. A change in make-up water supply was made in the meantime, however, and evidently the same total solid and alkalinity concentrations safely carried in the boiler when using the former water were not low enough to prevent carryover when a water having entirely different characteristics was substituted.

Roanoke, Va. S. H. COLEMAN.

The National Cost of Belt Slip and Friction

WE ARE often told that "little losses" are, in general, responsible for the large aggregate losses. We spend a penny here and a penny there, and before we know it we have nothing left. Hence Benjamin Franklin's wise counsel: "A penny saved is a penny earned." It was the late John D. Rockefeller, I believe, who originated the saying, "Save the pennies and the dollars will take care of themselves." Without doubt, John D. "knew his onions."

All of which should give us good cause to investigate a tiny loss that is often mentioned—belt slip. Unquestionably, one easy way in which this nation could save a surprising amount of fuel annually would be by the total elimination of belt slip. To many readers this may sound like a trivial matter, but it is not trivial. It is important.

Power transmission belts are used in nearly every industry and they are used to such an extent that the

total estimated amount of energy transmitted by belts in the United States is 60,000,000 hp. This amount of power is actually greater than the primary horsepower used in industry owing to the fact that there are so many redrives. Thus a main belt runs from the engine or motor to the main shaft, then a secondary belt runs to a countershaft, and from that shaft another belt runs to the machine. Sometimes there are as many as five intervening drives. Therefore in a given 100-hp. plant the total capacity of belt drives may be 300 hp. or even more.

On the basis of $42 per horsepower per year for plants operating 10 hr. a day and 308 days per year, the total cost of this power to the nation is $42 × 60,000,000 = $2,520,000,000 anuually.

Now let us, as a nation, eliminate all belt slip, which *can be done*. There is not much excuse for permitting belt slip, as has been proven time and again. Yet despite such proof, belt slip goes merrily on, everywhere.

Assuming, however, that the nation would eliminate all belt slip, this is the saving that would result:

$$\$2,520,000,000 \times .02 = \$50,400,000$$

In the above calculation I am assuming the average belt slip throughout the nation to be 2 per cent. In reality it is doubtless greater than 2 per cent, but to be safe and to avoid exaggeration I am using 2 per cent. In "round figures" we can therefore safely say that the cost of belt slip in the United States is greater than 50 million dollars annually.

Of course this loss is *not* a money loss. All of the money, I dare say, remains within the boundaries of the United States. But it is a serious fuel loss. It means that $50,000,000 worth of fuel has been unnecessarily burned, never to return.

Similarly there is a tremendous, unnecessary, and irretrievable waste of fuel each year due to bearing friction. Lubricants are now available that lubricate with much greater efficiency and economy than is generally realized. Anti-friction bearings are also available. Every belt drive has a bearing at each end. These bearings are responsible for the efficient transmission of 60,000,000 hp. The use of lubricants which really lubricate, and the use of modern bearings will save at least another 2 per cent of power, making the total annual saving over $100,800,000 to the nation.

Which means, again, the saving of over $100,000,000 worth of fuel. Expressed in terms of coal valued at $200 per carload this would be 500,000 carloads of coal, or, 5000 trainloads of coal, 100 cars in each train.

Newark, N. J. N. G. NEER.

Trade or Profession

READING JAMES G. GIBBONS article "Is Engineering a trade or profession?" brought to mind that about 20 yr. ago that question was frequently before readers of engineering journals.

Being a power plant engineer and operator of energy transformation devices designed by professional engineers, I can with emphasis say that their field of endeavor is not a trade although they have a sort of union.

All those who have noticed the tremendous advancement in technology, in which the professional engineers have been the main factors, are without a doubt willing to recognize any title that they may wish to add to their names.

The engineers referred to, however, are also familiar with the fact that psychology is of great importance in our modern society and aware of the technique for its successful application.

Anyone who wishes to discover will find that the possessors of great technical skill usually have titles which are absorbed by accomplishments.

Philadelphia, Pa. B. HJORTH.

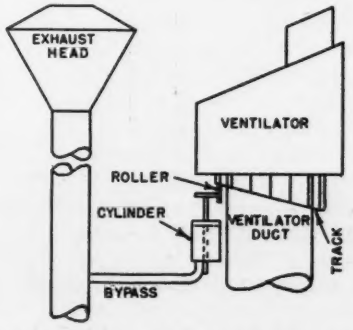
Plank in Boiler

I HAVE no doubt that the reader has been troubled with many an engine that had a knock but it is unusual for a boiler to behave that way. This was in a railroad round-house. The night engineer had just come on and there was a newly cleaned boiler to fire up and put in service. After cutting the boiler in, when it began to take the load it let out a thump at regular intervals, much to the amazement of the engineer. He was worried and called up the master mechanic to ask him what they had done to the boiler that day. The master mechanic said nothing except cleaned it and put in a new feed line. They cut out the boiler and the next day opened it and found,—the mechanic had run a plank in on top of the flues to lie on while he screwed the feed line in place and, after he was through, his helper picked up the tools but forgot to take out the plank, which was floating on top of the water and every little while would wham against the back head when the boiler was making steam and make the knock complained of.

Logansport, Ind. C. C. CUSTER.

Ingenious Rotator Saves Rebuilding Job

WHEN spoilage of product was traced to condensation entering packing room ventilators from an elevated exhaust head, and it was further proved that the uprush of air caused by the exhaust turned the ventilator cowl to face the steam line and thus tend to



Mechanism used to face the ventilator away from the steam line

trap falling moisture whenever there was no breeze blowing, it looked as though there'd be a realinement of ventilators, and a shift of the offending exhaust line.

Since both ventilator and exhaust were most advantageously located, the engineer rigged up a simple yet ingenious mechanism which automatically faced the ventilator away from the steam line during a calm.

Through the bypass taken off the exhaust riser, steam, under the pressure of the muffler, was admitted to a cylinder carrying on the upper end of its piston rod a roller. This roller pushed against an inclined track suspended from the cowl and so set as to have its highest point at the heel of the hood or cowl. With steam in the cylinder and the rod at its highest point the pressure on the track would hold the cowl directed away from the steam line, the exhaust pressure exerting force enough to cause the inclined track to tend to revolve the cowl and permit piston motion until the end of the stroke was reached.

When wind pressure on the vane exceeded the urge of the roller, the cowl would face with the wind, as formerly, and thus ventilation remained unimpaired.

Longview, Texas. M. T. PATE.

Buring Cocoa Shells

COCOA SHELLS having high calorific value and a very low commercial value had to be disposed of. Shoveling them into the coal fire would result in dense cloud of smoke and a rapid rise of the steam pressure. Selling the shells did not pay the cost of bagging and shipping. But the coal bill was found too high, as anywhere in most steam plants with hand-firing. So I worked out the contraption as illustrated on the attached diagram.

It works fine, saves approximately 30 per cent of the coal-pile, does not damage the boiler shell nor the furnace lining, results in a clear fire, a haze of bluish white smoke and a high rate of evaporation. There is no blow torch action as with oil-burners. The cocoa shells are fairly well distributed over the fuel bed, but must be burned with glowing coal on the grate. Steam consumption is very low and negligible.

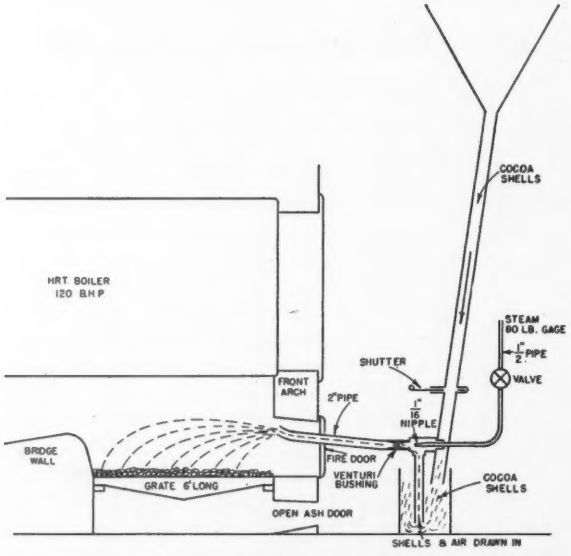
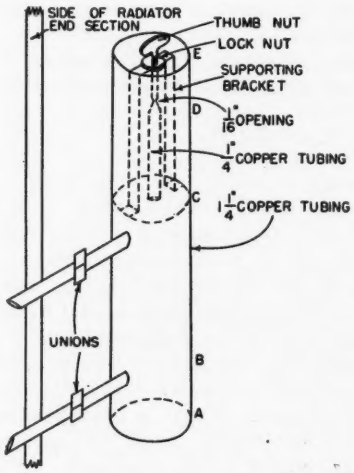


Diagram of makeshift stoker which is used to feed cocoa shell into a hand fired boiler

Brooklyn, N. Y. H. ETTELT.

Simple Humidifier for Power Plant Use

SHOWN in the attached sketch is a humidifier which was built by our mechanics using material available around the plant. It was installed in a large billing room where low humidity during the winter months caused considerable annoyance to employees. The unit functions remarkably well for such a simple device and is quiet in operation.



Humidifier construction

Permitting drops of moisture to get onto the floor is the common fault eliminated by a steam chamber with condensate drain which evaporates the water collected in the shredded asbestos wicking that fills the space from C to D. The steam space is, of course, from A to C with the section A to B being filled with condensate.

Construction of the device is very simple, soldered fabrication being satisfactory. Of course, the tube will have to be cut and resoldered at a point below C for the fastening of the supporting plate.

Hibbing, Minn. A. L. BENNETT.

ILLUMINATED by acetylene, thousands of giant steel buoys are afloat in waters surrounding the American continent. This gas burned in air, using a suitably designed burner, gives a brilliant white light which more closely approximates sunlight in color value than any other type of man-made illumination. Since it would be too great a feat to ignite and extinguish these lights by hand, they are operated mechanically by almost human sun valves. These valves automatically turn on the beacon when the sun goes down, and off at sunrise.

Horsepower and Kilowatts

THE SUPERINTENDENT stepped into the power house and asked Harry, the engineer: "Just what did our process water cost us last year?"

"The exact cost was $3798.75," answered Harry, wondering what trouble was brewing.

"That's just about $1000 too much," snapped the superintendent. "Five years ago when you brought up the well idea it was a saving—but that's no reason to let it run year after year without checking up to see if we can do better."

"What's the matter with our well? It's never given us a minute's trouble, the water is clear and the only cost is for electric power."

"That's just it; it costs too much to pump water up from a depth," explained the superintendent. "Now, I've been watching the brook at the end of the east yard for the last two years and I found there was plenty of water there right through the draught. There you have a supply of water right above the ground, so why should we pay to pump it up?"

"Well," said Harry. "We wouldn't gain anything. Why it's a thousand feet from the brook to our water main."

"That's what you think. But, last week end while you were away fishing I had a centrifugal pump expert here and he made up a proposition that a centrifugal pump be installed at the brook and piped to the main. He then guaranteed to deliver all the water we are using with a twenty-five horsepower motor. Now 25 horsepower is 18.68 kw. which at 3.2 cents makes our pumping cost only 59.68 c. per hr. and in our 4800 hour year the total cost would be just $2865.00 and that, Harry, is a saving of $933.75 a year—I'm afraid you're slipping to miss a saving like that."

"But what about the cost of the pump, motor and installation?" sputtered Harry, caught off guard.

"The deep well pump was an expensive outfit and the centrifugal pump salesman has a customer who wants it and it works out as a straight exchange with 1000 ft. of good used pipe thrown in."

"I want to check up on this a bit," said Harry. "Give me until noon."

"Go ahead," agreed the superintendent.

When the superintendent returned from his lunch he found Harry waiting in his office: "Well?" he querried. "What is it now?"

"It's about that expert you had here while I was fishing," answered Harry with a grin. "He seems to have overlooked something."

"Oh! And what did he overlook?"

"We'll have to run a high tension line from the power house to the brook in order to run the motor and pump."

"Of course we will, but there's plenty of copper wire around and a few poles."

"I know that but the best I can do with the copper on hand would be to get 92 per cent efficiency out of the transmission line," explained Harry.

"That's good enough—don't expect anythng better."

"The step down transformers are 97 per cent efficient."

"Good."

"And 96 per cent for the low line, switch and leads."

"That is ok. Harry."

"The motor the expert proposes to furnish is 87 per cent efficient at full load."

"Say! What are you driving at?" asked the superintendent.

"Just this; 92% x 97% x 96% x 87% is 74.5% and dividing 746 by .745 gives one kilowatt at the switchboard for each horsepower at the motor and 25 kw. at 3.2 cents is 80 c. per hr. which for 4800 hr. amounts to $3840. The result of following your 'expert's' advise would be for us to pay $41.25 a year more for a lot of muddy water. I can't see any economy at all in the scheme: You'd better come fishing with me week ends and keep out of trouble."

Conchas Dam, New Mexico GEORGE P. PEARCE.

Reconditioned Lubricating Oil

NOT LONG ago oil refiners appeared to be somewhat worried about the inroads being made by the reclaiming of used lubricating oil. It was declared by some so-called experts that reconditioned oil was "just as good" as new oil, and in some instances that it was even better. It was feared that if the claims regarding reconditioned oil were true, that all lubricating oil would be used over and over indefinitely, and as a result, new oil would merely serve the purpose of make-up in about the same way that fresh water is occasionally added to the water of a cooling tower to keep the volume of water constant.

It now appears, however, that the present low cost of new lubricating oil has changed all that, for we now find that some manufacturers of reconditioned oil are obliged to go out of business because they cannot compete with the present low lubricating oil prices. In fact one concern of this writer's acquaintance which was doing an excellent business only a few years ago, recently sold its entire equipment for junk. Equipment that had cost thousands of dollars was sold for a few hundred. It couldn't be sold for any other purpose because there is no demand at present for reconditioning oil equipment.

Low cost of new oil, however, is not the only reason why new oil is preferred. For the same reason that certain crudes are difficult to refine—crudes that have a high sulphur content for instance—used oils often contain impurities that cannot be easily removed. As a result, to make such lubricants safe and satisfactory, the correct purifying process is so expensive that competition with the new oils is impossible. Careful buyers prefer new lubricating oils even though the first cost of the new oils may be higher.

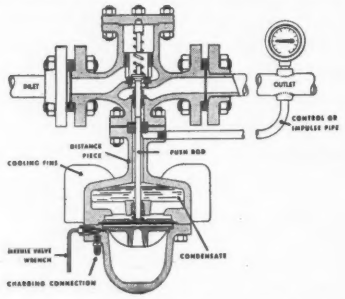
Newark, N. J. W. F. SCHAPHORST.

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Reducing Valve

THE GROVE REGULATOR CO., 1729 Poplar Street, Oakland, Calif., has announced its new steam reducing valve designed to handle all pressures up to 1500 lb. SWP, 950 deg. F. The design is unique in that no springs or counterweights are used to motivate the valve; use is made of an air dome, a dome plate with orifice and a so-called Grove-Boyle Power Chamber.

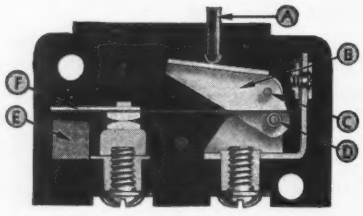


It is said to give smoother outlet pressures, have greater sensitivity, freedom from valve chatter and automatic shut-off in case of diaphragm rupture. A single-seated valve is used. Pressure within the air dome is present to equal the desired outlet pressure and this pressure pushes against the valve stem to open the valve. Because its diaphragm is supported on both sides by nearly equal pressures use can be made of the newer highly flexible synthetic diaphragms.

Compact Snap Switch

A SWITCH ACTION, which was originally developed as a part of McDonnell Low Water Cut-offs, has been made the basis of a "snap" switch of the compact, low operating pressure, short-travel type. The switch is now available in a number of types as original equipment for manufacturers using switches of this kind.

The basic consideration in the design of the switch was to accomplish a quick make or break with a wide air gap, while still retaining the advantages of highly sensitive, short-movement operation. The sectional illustration shows how this has been done. The plunger (A) acts on the lever (B) which is pivoted at point (C) so that the roller (D) communicates the operating action to the under side of the special alloy spring (F) on which one of the contacts is mounted. At the end of the spring there is an iron armature which is attracted to the permanent "Almico" magnet (E). This magnet holds the switch in contact until the precise point is reached where the pressure on the spring overcomes the pull of the magnet. At this point (characteristic of a magnetic field) the spring "kicks" to its upper limit instantaneously. Similarly, when closing the action is instantaneous when the spring comes within the influence of the permanent magnet.

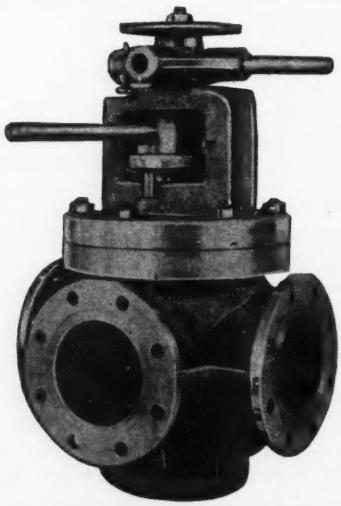


The construction and operating characteristics are covered by a circular which may be obtained by writing McDonnell & Miller, Wrigley Building, Chicago.

Lift-Plug Valve

A NEW line of three-way brass Homestead Easy-Turn Lift-Plug Valves has just been developed by Homestead Valve Mfg. Co., Corapolis, Pa., for use on air, water, oil, and gas services at working pressures up to 150 lb. and temperatures below 400 deg. F.

The valves are available in sizes from 1¼ to 3½ in. and with three different styles of port arrangement—Style D, which permits flow from either end and out the side opening, or vice versa; Style E, which permits flow from the left hand end and out the side opening or straight through; and Style F, which permits flow from the right hand end and out the side opening, or straight through.



Direction of flow is changed by a quarter-turn of the operating lever. The powerful leverage and screw of the Lift-Plug feature not only assures easy operation, but permits the plug to be sealed in the body in either of its two extreme positions of travel or in a mid-position so that all ports are closed.

Wrench

THE INTRODUCTION of Bonney Zenel TuType Wrenches several years ago in four sizes with openings from 7/16 to 5/8 in. proved so popular and the demand so great for wrenches of similar type in a wider range of sizes that Bonney Forge & Tool Works, Allentown, Pa., recently announced a complete new line of Tu-Type Wrenches.

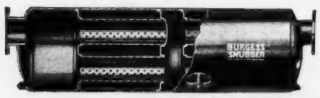
Drop forged of Bonney "CV" Chrome-Vanadium Steel in 13 sizes, they have openings ranging from 3/8 to 1 1/16 in. Combining an open-end and box wrench, each with the same size opening in a single tool, the advantages of this type of tool are readily apparent to the experienced mechanic. It permits using the end most applicable to the job at hand.

The box end has double-hexagon opening and is offset at 15 deg. to give proper clearance for obstructions. The open end is angled at 15 deg. for efficiency.

The oval handles are long and thin and shaped to provide a firm, comfortable grip. All wrenches have full chrome-plated finish, with highly polished heads and will retain their finish indefinitely.

Intake and Exhaust Quieting

A TOTALLY new type of noise-quieting device which is non-acoustic and can be placed at any point in the intake or exhaust system of an engine or compressor, has recently been developed by the Acoustic Division of the Burgess Battery Co., 500 W. Huron St., Chicago, Ill. Since it eliminates the cause of noise produced by the pulsating gases by snubbing the peak velocities and pressures and thereby produces a smooth flow of gas, this new device is called the Burgess Snubber.

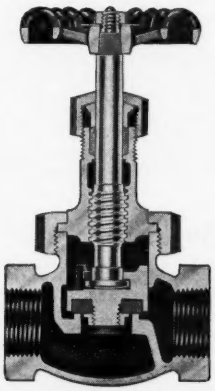


The effect of the Burgess Exhaust Snubber is to prevent the sudden impact of the slug of vented gas with the atmosphere and also to stop the usual inrush of air into the exhaust pipe, after the discharge of the slug. Therefore, the sharp noise of the slug impact and the rumbling noise of the vibrating air column in the exhaust pipe are eliminated.

The same type of unit is applicable to intake and output lines of reciprocating and rotary compressors. Burgess Snubbers are available in a wide range of sizes for standard, heavy duty, and spark arresting service.

Bronze Valve

THE OHIO INJECTOR CO., Wadsworth, Ohio, has just introduced a new bronze union bonnet composition disc globe valve. The new valves are available in globe, angle, horizontal check and angle check (Figs. 520, 521, 516 and 517, re-



spectively) designs in a full range of sizes from ⅛ to 3 in., inclusive. One of the fifteen features of the valve is the 8E composition disc suitable for steam working pressures of 200 lb. at 400 deg. F. total temperature up to hydraulic pressures of 400 lb. It is suitable for steam, water, air, oil and gas, is resistant to a large number of chemicals and can be replaced with any standard OIC composition disc.

Reducing Valves

NORTHERN EQUIPMENT CO., Erie, Pa., announces a complete new line of Copes Valves for steam and water pressure reducing service.

The Copes Type DBI Valve, a direct-operated, spring-loaded unit, is designed for controlled pressures from 2 to 50 lb. Regulation from fully-closed to wide-open is not more than 10 per cent of the controlled pressure; not less than 0.5 lb. Sizes from ¾ to 10-in. are furnished in the 125 to 300 lb. pressure standards.

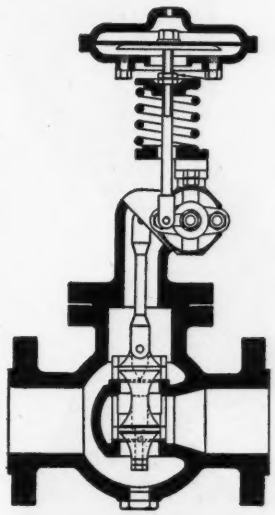
The Copes Type DSLH Valve, a relay-operated, spring-loaded unit designed for the same pressure limits, is used where the reducing valve is subjected to a high excess pressure. It will operate dependably with pressure drops as high as 1200 lb. Regulation is not more than 5 per cent of the controlled pressure; not less than 0.5 lb. Sizes 1 to 14 in. are furnished in the 125 to 1500 lb. pressure standards.

The Copes Type S-1 Valve, a direct-operated, spring-loaded unit, is designed for controlled pressures from 15 to 250 lb. Regulation from fully-closed to wide-open is not more than 10 per cent of the controlled pressure; not less than 4 lb. Sizes ¾ to 6 in. are furnished in the 125 to 400 lb. pressure standards.

The Copes Tvpe 3-SH-2C Valve, a relay-operated, spring-loaded unit, designed for the same controlled pressures as the Type S-1, is used where there is a high pressure drop across the reducing valve. It is suited for excess pressures up to 1200 lb. Regulation is not more than 5 per cent of the controlled pressure; not less than 2.5 lb. Sizes 1 to 14 in. are furnished in the 125 to 1500 lb. pressure standards.

The Copes Type W-DBI valve, a direct-operated, weight-loaded unit, is designed for controlled pressure limits from a vacuum of 27 in. to a gage pressure of 10 lb. Regulation from fully closed to wide-open is not more than 0.4 lb. Sizes ¾ to 10 in. are furnished in the 125 to 300 lb. pressure standards.

The Copes Type WS-1 Valve, a direct-operated, spring-loaded unit, is designed for controlled pressure limits of 10 to 125 lb. Regulation from fully-closed to wide-open is not more than 6 lb. Sizes ¾ to 4 in. are furnished in the 125 to 400 lb. pressure standards.

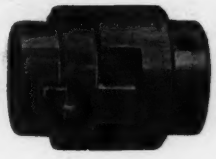


Where remote control of the pressure reducing station is required, three Copes Master Controls have been designed to cover a controlled pressure limit of 2 to 600 lb. ga. Regulation with these master controls, from fully-closed to wide-open, is not more than 5 per cent of the controlled pressure; not less than 2.5 lb. Two relay-operated, spring-loaded valves are used with these controls. The Copes Type R-DBI, furnished in 1 to 10 in. sizes in the 125 to 900 lb. pressure standards, is used where the pressure drop across the reducing valve will be moderate. The Copes Type R-DSLH, furnished in 1 to 14 in. sizes and in the 125 to 1500 lb. pressure standards, operates with pressure drops as high as 1200 lb.

Safety Flexible Coupling

A NEW FLEXIBLE COUPLING for handling misalinment, starting torque, absorbing shocks, etc., on direct connected machinery which the manufacturer says will provide increased safety and lower maintenance is announced by the Lovejoy Flexible Coupling Company, Chicago.

In certain industries where explosive and inflammable gases, vapors and liquids

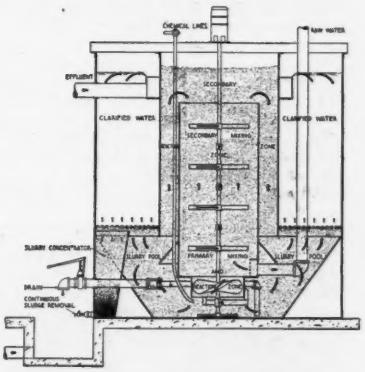


are handled, indications are that flexible couplings with iron or steel bodies are not entirely safe because of the possibility of a spark being created by some accidental contact with the iron or steel coupling. The body of this new L-R flexible coupling is made of Tobin bronze. This metal will not "spark" under any conditions. The spider or resilient load cushion is made from rubber, duck, leather or a brake lining material of woven asbestos. The three-piece construction makes assembly and installation quick and easy. The spider member has sufficient resilience to safeguard the connected machines against overloads and misalignments. The couplings are quiet in operation and require no lubrication.

L-R Type I-A "Safety" Couplings are made in the standard sizes with bores from 1 in. to 2¼ in., inclusive. (2 hp. to 90 hp. at 1750 r.p.m.)

Water Softener

THE ACCELATOR, a new and advanced water softener developed and manufactured by International Filter Co., 59 E. Van Buren St., Chicago, Ill., now is available in a range of capacities to satisfy all requirements. The underlying principle of the accelator is an entirely new treating method. Treating chemicals are applied to the water in a new way. Reactions occur under new conditions. Unlike conventional lime or lime-soda



processes, sedimentation is not employed in the accelator, it is stated. Instead, water is actually squeezed from the top of a recirculated pool of slurry. With this process, means are provided to hasten greatly or accelerate the chemical and physical reactions involved. And because of this, space requirements are reduced. This of course brings about a corresponding saving over the cost of treating plants requiring greater area and volume.

Self-Lubricating Bearing Bronze

UNDER the name Ledaloyl is presented a new bearing material in which lead and graphite are included in the alloy, the manufacturing process giving a definite alloy of porous character and the pores being filled with high-grade oil by submersion in vacuum tanks. This porous capillarity permits flow of oil to the shaft when needed and absorption when not in use. A booklet tells about properties and applications of the material in bearings. Johnson Bronze Co., New Castle, Pa.

Polarized Field-Frequency Relay

A NEW IMPROVED relay for controlling the application and removal of direct-current field excitation for industrial synchronous motors has been recently developed by Electric Machinery Mfg. Co., Minneapolis, Minn. This relay enables the synchronous motor to exert its maximum effort to pull its load up to synchronous speed, in the minimum time. It eliminates backlash to the driven machinery and reduces voltage disturbance on the power line during synchronizing of the motor.

The new relay is of the "polarized field-frequency" type. The polarized action of the relay makes it selective to apply field excitation at the most favorable angle between the stator and rotor poles of the synchronous motor to pull the motor promptly into synchronism without pole slippage. The relay uses also the frequency of the current that is induced in the field winding of the synchronous motor during starting to apply excitation at the right motor speed for synchronizing.

Should a momentary voltage dip or overload pull the motor out of step the polarized field-frequency relay also removes excitation automatically. This allows the motor to resynchronize—thus avoiding shutting down the motor.

Clamp-Ammeter Measures High or Low Values

THE NEW, bakelite encased A.C. clamp-ammeter, just announced by Weston Electrical Instrument Corp., Newark, N. J., combines 6 ranges in one instrument, and will measure current flow through conductors (insulated or non-insulated) up to 2¼ inches in diameter.

The instrument is equipped to measure low as well as high values. Actual full scale ranges are 10, 25, 50, 100, 250 and 500 amperes. Any one of these six ranges may be selected by use of the easily operated range changer located at the thumb position.

With a single conductor through the clamping jaws, current values from 1 to 500 amperes can be conveniently read. Additional lower ranges may be secured by passing the conductor through the split-core transformer (clamping jaws) two or more times. For example, 2 turns produce 5 amperes full scale; 4 turns, 2.5 amperes full scale.

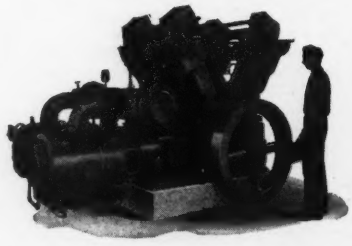
The clamp-ammeter is designed to be used at all commercial frequencies. When used at frequencies between 50 and 70 cycles, accuracy is guaranteed at 3 per cent or better. Slight deviations caused by the position of the conductor are included in this 3 per cent overall accuracy. Well compensated for temperature variations, the instrument may be used at temperatures ranging from 32 to 110 deg. F. with less than 1 per cent error.

The instrument used is the standard Weston Model 301, designed for ruggedness and dependability. The clamp-ammeter has been subjected to voltage breakdown tests of 2,500 v. a.c.; thus it may safely be used on 660 v. a.c. with ample safety factor.

Developed in conjunction with local public utilities, the new Weston clamp-ammeter is expected to find wide application in industry, particularly for use in inaccessible places and where it is necessary to obtain measurements without interrupting the circuit.

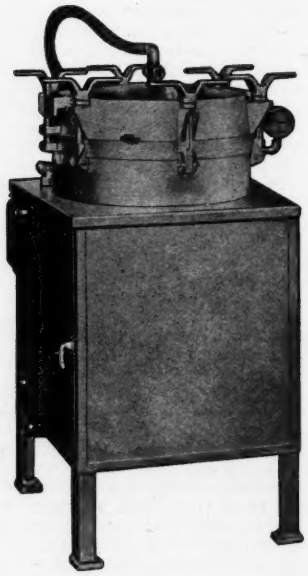
Heavy-Duty Diesel Engine-Driven Compressor

A NEW heavy-duty Diesel-engine-driven compressor, known as the "XVO" has just been announced by the Ingersoll-Rand Co., 11 Broadway, New York, N. Y. This machine is suitable for use in independent or isolated compressor plants, or when existing power facilities are overloaded. It is recommended for use in mines and quarries, construction and contracting, drill barges, ice and cold storage plants, air-lift pumping and general industrial service. The "XVO" is entirely new in design and combines a horizontal heavy-duty double-acting compressor with a heavy-duty "V" type four-cycle Diesel engine in a single compact and comparatively lightweight unit which operates at a moderate speed. Sizes are available for actual-free air delivery ratings of 625, 935 and 1250 c.f.m. for 100 lb. sea-level compression. In addition, a wide variety of air, gas, and ammonia compressing cylinders is available for pressures ranging from vacuum to 5000 lb. per sq. in. and higher.



Oil Reclaimer

THE HILLIARD CORP., 105 Fourth St., Elmira, N. Y., has entered the stationary Diesel engine and steam turbine field with a complete new line of Hilco Oil Reclaimers. It is claimed to be a simple method of restoring contaminated lubricating oil to the full value of new oil.



The Hilco Reclaimer incorporates many important features of design in connection with the Fuller's earth type of oil purifier, such as being all-electric and automatic and continuous in operation. It lends itself to direct-connecting to Diesel engine and steam turbine lubricating systems for continuous or intermittent by-pass purifying to keep the oil perfectly clean at all times. It can also be operated as a batch reclaimer.

Filtration through Hilite results in the removal of carbon, sludge, resins, gums, acidity and restores color. This type of filtration is referred to as "adsorption." The last traces of moisture and fuel dilution are removed in a vacuum chamber which removes the diluants at a low temperature. Hilco reclaimers are made in various sizes to take care of the smallest to the largest Diesel or steam turbine installation.

Low-Voltage Protector Tubes

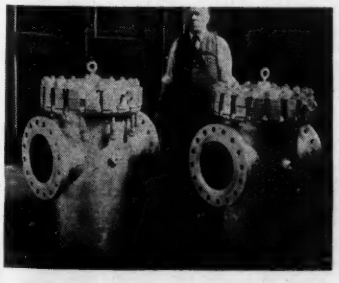
A GAS-FILLED protector tube especially designed for indoor service has been developed by Westinghouse Electric & Mfg. Co. to protect supervisory control line wires and telephone lines from overvoltages caused by lightning and direct contact with or induction from nearby power lines.

The protector is of the discharge-gap type with the gaps enclosed in a glass bulb containing inert gas at a low pressure. The gas used is easily ionized and provides a current-carrying path of 50 amp. for 2 sec. Where induction is especially severe, the line wires may be continuously grounded through suitable transformers in conjunction with the protector units and all dangerous induction drained off directly.

One electrode is connected to ground and the other two to the lines being protected. When an abnormal voltage disturbs the line, the tube breaks down and discharges the disturbance to ground, ceasing to discharge when the voltage of the disturbance is reduced. It is recommended that a resistor of 60 ohms be placed in series with the line to prevent possible short circuit of the supply source through the tube when discharging any disturbance; also, that 10-amp. fuses be used in the supply end of the line as protection in the event of a breakdown of the equipment.

Strainers for Boulder Dam

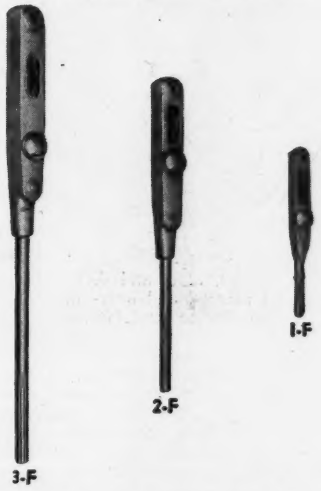
MAMMOTH basket type water strainers shown in the accompanying picture feature a new type of detachable cover that was developed recently by the Davis Regulator Co., Chicago, Ill., to meet the special requirements of engineers supervising construction on the Boulder Dam project. As will be noted, the cover bolts are of the Eye-bolt type which fit in slotted openings in the cover and body flanges. Merely by loosening the nuts a few turns, it is possible to swing all the bolts away from the cover so it can be removed and replaced in minimum time. This was considered necessary there because of the need for virtually continuous service.



The high pressure strainers are connected in the line from the turbine penstock for supplying high pressure service water in the Boulder Power Plant for turbine seals, operating water for eductors and other uses where high pressure or moderate pressures are required. The low pressure strainers (not illustrated) are on the suction of the eductors taking water out of the tail race.

Tension Indicator

THIS new tension indicator, available in three sizes, is an improved type of tension indicating wrench designed to tighten bolts to a predetermined stress with each bolt carrying its proportionate share of the designated load, thus providing uniform tension. In bolting or tightening cylinder heads, flange connections, main bearing supports, connecting rods or any other parts where control must be maintained over steam, gas, water, oil or air, the need is apparent for uniform tension which can be provided with one of these tools manufactured by the Automotive Maintenance Machinery Co., North Chicago, Ill. The indicator provides for uniform tensioning on the job so that the stress on bolts can be definitely known in service operations. It prevents distortion, insures accuracy, maintains compression and prevents fuel loss in motors and machines.



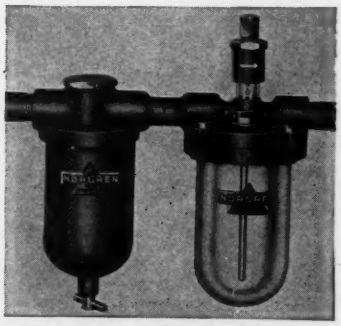
Cooling Water Control

THIS new regulator, known as type TR-40, made by Sarco Co., Inc., 183 Madison Ave., New York, N. Y., has been designed expressly for use on the cooling water jackets of internal combustion engines and compressors, also for water cooling of solvent recovery stills in dry cleaning plants and on degreasers as used in metal manufacturing establishments. The control consists of a piston valve operated by a liquid expansion thermostat to throttle the flow of controlling water as required to maintain a constant temperature The valve is provided with a bleeder port adjustable from the outside. This serves to allow a small amount of cooling water to flow at all times even when the valve is closed, which also keeps the thermostat active and ready to respond. An important innovation is a safety device in the form of a fusible plug inserted between the thermostat plunger and the valve spindle so that, in the event of thermostat failure, the plug will collapse and the water valve will be forced wide open, making impossible damage to the engine in the event of thermostat failure. Sizes ⅜ to 1 in. are now available and larger sizes are contemplated.

Strainer & Lubricator

A COMBINATION of two new devices is designed to condition air for the efficient operation of air tools. These are the Norgren air strainer and theNorgren sight feed automatic air line lubricator.

The strainer, offered in ¼ to ⅜ in. sizes, consists of a double screen, a bronze head, and a drawn steel, tin-dipped bowl. A 200-mesh monel screen is supported by a 100-mesh brass screen. Effective straining area is five times greater than inlet and outlet openings. Screen element easily removed for cleaning by unscrewing the top. Sump may be blown out by turning T-handle valve at the bottom.



Following in general the patented design of the regular Norgren lubricators, the new lubricator has the added feature of a transparent oil reservoir of resilient plastic which withstands the Underwriters' 500-lb. burst test and is suitable for installations in temperatures up to 180 deg. The oil feed is controlled by a simply adjusted needle valve which is also in plain sight, revealing the exact amount of lubricant being introduced to the air stream. Filler plug in reservoir top makes refilling easy. Even with the air line in use, new lubricant may be added without any blow-back or spray. The new design of lubricator is now available in ¼ in., ⅜ in. and ½ in. sizes for horizontal lines. Strainer and lubricator are made by C. A. Norgren Co., Inc., Denver, Colo.

Small Mercury Arc Rectifier

A SMALL capacity, permanently evacuated rectifier unit using a substantial, heat resistant glass bulb as a vacuum chamber has just been put on the market by the Rectifier Division of Allis-Chalmers Mfg. Co., Milwaukee, Wis. The air-tight bulbs used in these new rectifier units require neither vacuum pumps, vacuum gages nor cooling water, as they are adequately air cooled by means of a small fan of simple construction.

The complete unit consists of the glass bulb, resiliently mounted, in a readily accessible truck-type framework located waist high in the upper portion of the cubicle structure. The lower portion contains the cooling fan and the small panel supporting the ignition and excitation devices. The necessary transformers and circuit breakers that go with the unit may be placed in any convenient location adjacent to the cubicle.

These permanently sealed, pumpless

rectifier units are at present being offered in convenient sizes ranging from 50 kw. at 250 v. to 300 kw. at 600 v., or even higher voltages furnished in completely factory wired and assembled cubicles. For larger power requirements several units may be operated in parallel.

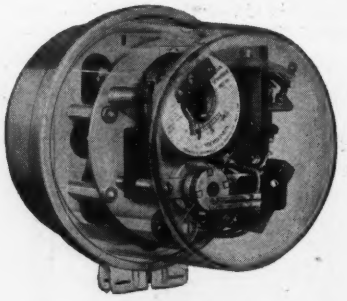
The ability of these small capacity, pumpless rectifier units to stand high peak loads and to give high efficiency at low loads makes them particularly suitable for applications involving otherwise uneconomical conversion problems.

Nickel Alloy

EASILY fabricated in its soft state, a new nickel alloy takes on a high degree of strength and hardness following simple hardening treatment. It is now offered in various fabricated forms and different degrees of temper by the Driver-Harris Co., Harrison, N. J. Such forms are available in soft, half-hard and full-hard tempers to meet intended fabrication and application requirements. Since the extremes of initial softness and ultimate hardness determine the full value of this alloy to users, exceptional care is taken in rolling and drawing operations. In the unhardened or quench-annealed state, "Z" Nickel is as readily worked as nickel, including bending, drawing, machining and hot forging. When heat treated, however, at low temperatures of 890 to 930 deg. F., it attains a hardness of Rockwell C 35-45, at which levels it is 2½ to 4 times as strong as structural carbon steel and possesses good toughness.

Ultra-Sensitive Relay

THE MICROTROL RELAY, housed in a weatherproof case, makes available for the first time a completely automatic, ultra-sensitive controller, entirely self-contained. The input relay (Model 705) will operate on values from 2 microamperes up and from 0.5 millivolt up. The power relay contacts will safely handle 5 amperes at 110 volts a. c. non-inductive. Made by the Weston Electrical Instrument Corporation, Newark, N. J., this relay is widely applicable in various circuit functions such as the control of automatic doors, smoke alarm or liquid



density control, a. c. and d. c. voltage or current alarms, and over- or under-temperature thermocouple failure.

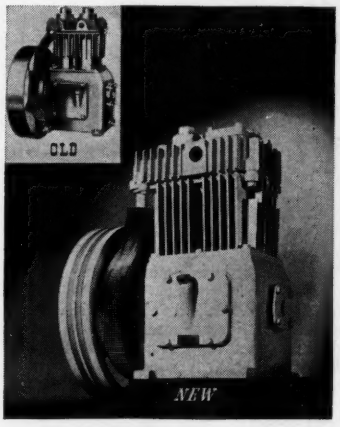
The Microtrol relay, combining the Sensitrol relay Model 705 and the power relay Model 712, is designed for an operating interval in which the power relay will open and close once each four seconds. The relay will remain closed approximately three seconds and open one second. These time intervals can be changed, on special order, so that the device will close once each 15 seconds, once each minute, or remain closed continuously until conditions return to normal.

Available in the same ranges as the Sensitrol relay Model 705, the Microtrol relay is intended for use on 120 volt, 60 cycle circuits.

Complete information about the new Microtrol Relay, Model 726, may be obtained by writing the Weston Electrical Instrument Corporation, Newark, N. J.

Air Compressors

NINE NEW and improved Quincy air compressors have been announced by the Quincy Compressor Co., Quincy, Ill. These distinctive examples of modern machine design are the result of a conviction on the part of the manufacturer that air compressors deserve to be as good looking as they are efficient. In addition to their compact, more business-like appearance, improved over-all efficiency is claimed. This is the result of many important mechanical refinements which include simplified construction, 12 per cent greater radiation area on cylinders, a more thorough and more positive constant level oiling system, totally enclosed, dust proof crankcases and non-breakable, cushioned discharge valves that make operation smoother and quieter.



When furnished for automatic start and stop operation, these compressors come equipped with a loadless starting device which automatically withholds all load from motor until it reaches full speed. This device also eliminates the need for check valves. Sizes range from 2.8 to 30.1 cu. ft. per min. piston displacement. Single stage—single cylinder, single stage—duplex cylinders and two-stage models are available in wide variety of standard and special mountings.

News from the Field

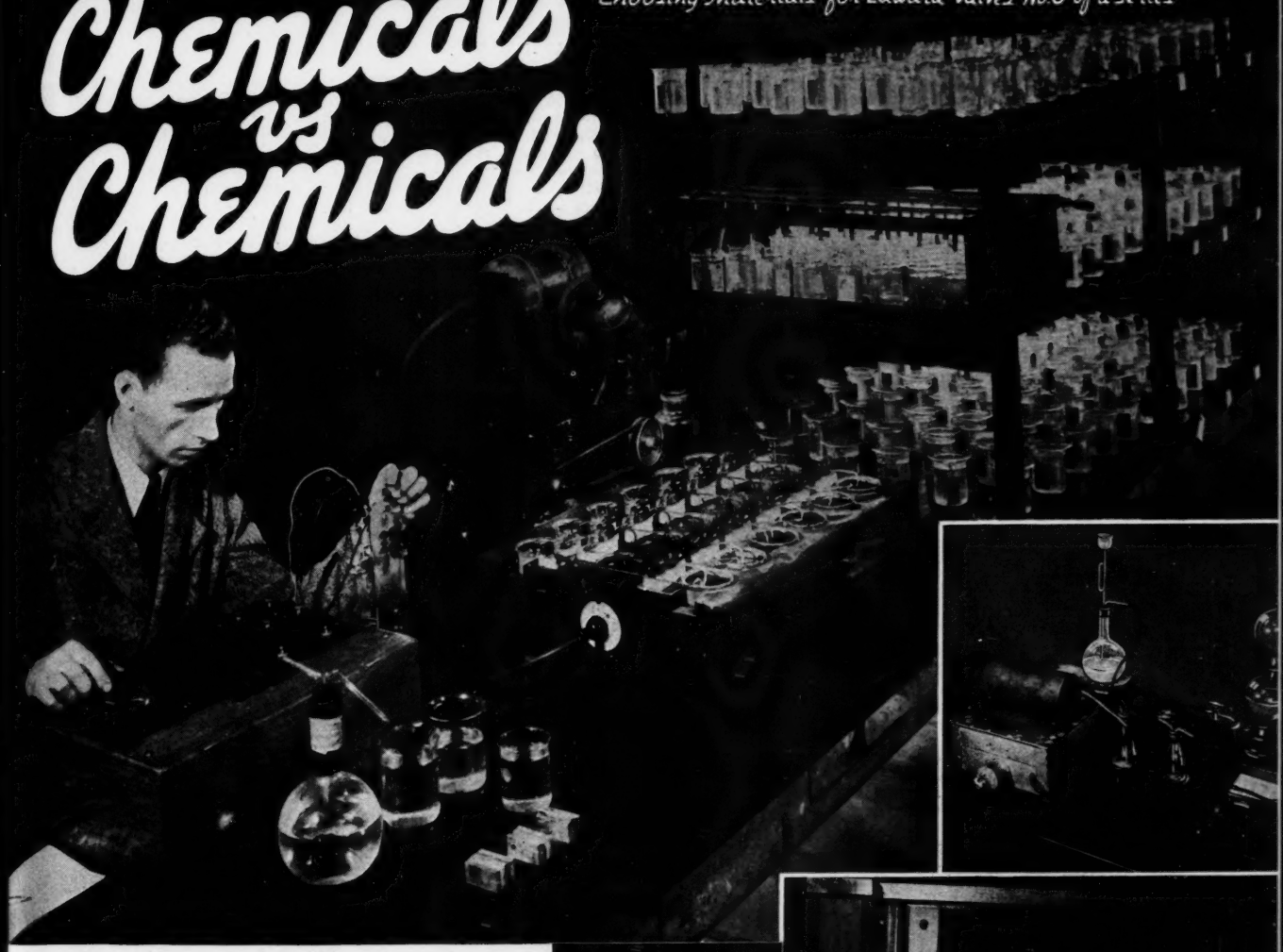
THE GREEN FUEL ECONOMIZER CO., INC., Beacon, N. Y., announces the election of John M. Birkenstock as vice-president and general manager. He is a graduate of Stevens Institute of Technology and has been associated with the company as a sales engineer since 1924. Clinton S. Messler, vice-president and chief engineer, takes charge of production.

FOOTE BROS. GEAR AND MACHINE CORP. announces the appointment of A. C. Andrews, 1613 Bryan Street, Dallas, Texas, as representative for the Northern half of the state of Texas and W. M. Lee, 1409 California Avenue, Houston, Texas, as direct factory representative and engineer covering the Houston territory; Industrial Engineering Co., Professional Bldg., Charleston, W. Va., as factory representatives covering the Southern part of West Virginia.

WORTHINGTON PUMP & MACHINERY CORP. has announced the transfer of Edward Watson, refrigeration and air conditioning engineer, from the corporation's home office at Harrison, N. J., to its Atlanta District Sales Office. Mr. Watson will function in North and South Carolina, Georgia, Florida and Alabama.

Chemicals vs Chemicals

Choosing Materials for Edward Valves-No.8 of a Series



IT'S the chemicals of industrial processes versus the chemistry of valve materials. An aggressive war on corrosion advances daily in Edward laboratories, seeking to enhance more fully the economic values of Edward valves. Predetermining valve life, not only from the effects of stress – temperature – erosion, but from the ravages of corrosion, is a requisite of Edward technicians — men who know that their cardinal duty, through production control and developmental research, is to give top value for your valve dollar.

• • •

The Edward Valve & Mfg. Co., Inc.
EAST CHICAGO INDIANA

CHECKING CORROSION

Valve materials, in the form of ground specimens, are immersed in corrosive fluids. Chemist (above) checks pH values of solutions with precision potentiometer. On second shelf are valve alloys in aerated solutions. Pump supplies air to each beaker.

Duplicating service conditions to find out how hydrogen sulphide behaves under temperature is the intent of hookup shown in small photograph. Correct corrosion resistant valve trim can thus be predetermined.

Right: Specimens are accurately weighed before and after subjection to corrosive media.

EDWARD VALVES

Stop · Check · Blow-off · Non-return · Feed Line · Relief · Bleeder Line · etc.

CHARLES H. HUGHES, for many years research engineer and designer of equipment for Semet-Solvay Engineering Corp., has been employed as a consulting refractory engineer by North American Refractories Co., Cleveland, Ohio. Mr. Hughes is widely known in the by-product coke oven and gas industries for his work in coal carbonization, carbureted water gas, manufactured gas, and related processes.

RUSSELL B. TEWKSBURY, Chairman of the Board, of The Oster Mfg. Co. of Cleveland, Ohio, died Sunday, January 1, 1939, at his winter home in Sarasota, Florida. He was 79 yr. old. Mr. Tewksbury had been a resident of Cleveland since 1880 after his graduation from Princeton University and was one of the founders of The Oster Mfg. Co., in 1893, which organization has been engaged in the manufacture of pipe and bolt threading equipment since its inception. He assumed the presidency of The Oster Mfg. Co. in 1898, and held that position until 5 yr. ago when his son, Roger G., succeeded him and he became chairman of the board. Mr. Tewksbury was also a director of the Cleveland Tractor Co. and the Electric Railway Improvement Co. of Cleveland. Surviving Mr. Tewksbury, in addition to his wife and two sons, are a daughter and eight grandchildren.

W. J. KYLE, power sales engineer, Public Utility Eng. and Service Corp., died January 6 at his home in Chicago, after a long illness. Mr. Kyle was well known throughout the electrical industry, having been engaged in electrical engineering and public utility research and sales activities since 1900. In 1916 and early in 1917, he acted in an advisory capacity to the DuPont Co. in developing equipment and apparatus to produce chlorine gas on a large scale for the loading of gas shells. He served in a similar capacity to other chemical companies during the War, in speeding up the production of nitroglycerin and in devising means of absorbing the heat and chemical reaction of nitro-glycerin in the manufacture of dynamite. In addition, during the War period, he was adviser to the United States Shipping Board, and a consultant to the French High Commission on various technical matters.

In 1928 he became associated with Standard Gas & Elec. Co. engineering and service organization as power sales engineer, which position he held until his death.

THE EDWARD VALVE & MFG. CO., INC., East Chicago, Ind., announces the appointment of representatives as follows: W. E. Bowler, Witherspoon Bldg., Philadelphia, Pa., in the Philadelphia and Wilmington districts; and Frank W. Hoyt, Waverly, Pa., in the Scranton, Easton, Bethlehem Reading, York and Harrisburg districts.

FEDERAL Power Commission has received application from the city of High Point, N. C., for license to construct a 30,000-hp. hydroelectric plant on the Yadkin River near Winston-Salem and 26 mi. of transmission lines; financing to be a PWA grant of $2,921,600 and loan of $3,571,000. Dam 80 by 2520 ft. to give 70-ft. head for three 10,000-kw. units, with transmission at 69,600 v., 3-phase and distribution at 2300 v. are details of the development.

E. T. KEEFE, President of Underground-Steam Construction Co., Boston, Mass., died December 1 at his home in Newton, Mass. For the past fifteen yr., Mr. Keefe had been president of this company, engineers and contractors, serving principally power plants, district steam heating companies, state institutions and colleges on underground steam distribution lines. Prior to that he carried on a similar engineering and contracting business under his own name.

WORTHINGTON PUMP & MACHINERY CORP. has appointed Walter B. Strong to the position of assistant general sales manager. Formerly manager of the corporation's Export Division, in his new assignment Mr. Strong will continue general supervision of Export sales, and will also be identified with certain phases of domestic sales work.

NORTON Co. of Worcester, Mass., announces the following changes in the headquarter's sales organization of its Abrasive Division effective January 1, 1939: G. A. Park, formerly Assistant Sales Manager, has been appointed Eastern Sales Manager in charge of the territory east of and including the Pittsburgh district. R. M. Johnson, formerly Sales Engineer, has been appointed Western Sales Manager, and will have charge of the Cleveland, Detroit and Chicago warehouses and other western territories. A. G. Green of the Research Laboratories will take over the position of Sales Engineer formerly held by Mr. Johnson. W. R. Moore, as the newly-appointed General Sales Manager, will direct the activties of these three men. Mr. Moore will report to H. K. Clark, Vice President. W. T. Montague has been appointed Assistant Vice President. He will continue to supervise the staff activities of the Sales Department, including sales research, publicity, sales training and traffic,—reporting directly to Vice President Clark.

R. M. ALVORD, J. E. N. Hume and A. S. Moody have been appointed commercial vice-presidents of the General Electric Co. Mr. Alvord is manager of General Electric's Pacific District, consisting of California, Arizona and Western Nevada. Mr. Hume has been manager of the Industrial Department of the General Electric Co. since December, 1935. Mr. Moody has been manager of the Northwest District of the company since 1936, prior to which he was manager of the Northwestern territory.

FRANKLIN T. GRIFFITH, President of the Portland Electric Power Co., was named "Portland's First Citizen for 1938" by the Portland Realty Board. For the past 11 yrs., the Portland Realty Board has publicly singled out that citizen in its community who for outstanding public service in the current year and over a period of years has stood out from the crowd and been a wholesome example to others. The honor was conferred upon Mr. Griffith this year, not only for his constructive efforts in bringing about a program of cooperation between the Federal Power Project at Bonneville and the existing private enterprises, but also for his calm counsel in helping to solve knotty labor problems in other industries during the past year.

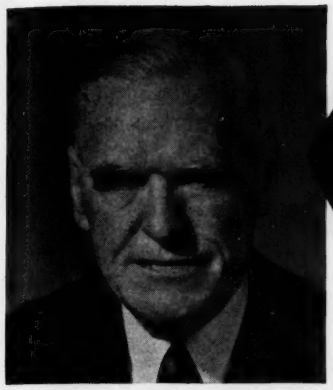
ESTIMATES by the Bureau of Mines indicate property losses of $200,000 per annum for stationary boilers and $500,000 for locomotive boilers for intercrystalline cracking of boiler steel. Ordinary water, not concentrated, does not cause cracking and concentrated water, such as in a boiler drum, will cause cracking only when it contains a peculiar balance of corrosive and protective film over the grain faces of the metal but with the grain boundaries exposed. A third essential factor is high stress in the metal. Dr. W. C. Schroeder in a lecture at the University of Maryland discussed research conducted on this subject and described a testing unit which has been developed for measuring the intercrystalline attack that may be produced by any boiler water. This testing unit may be attached directly to the boiler or it may be used in the laboratory.

FOR THE Coal Convention and Exposition of the American Mining Congress, to be held in Cincinnati, April 24-28, W. J. Jenkins, president of Consolidated Coal Co. of St. Louis has been named chairman of the program committee. Mr. Jenkins is a director of the Congress and of National Coal Assn., has been active in promotion of coal as a source of power and was a pioneer in the adoption of mechanical loading at his company's mines. Prospects for the coal industry are reported better than for 1938, with programs in view for 150 million dollars to be spent in modernization and improvement at coal mines. Over 5000 prominent coal mining executives are expected to attend the Cincinnati congress.

ALEXANDER RICHMOND HART, 84, former Long Island utility executive, died at his home in Garden City, L. I., December 26. He organized the Long Island Electric Railway Co. in 1894 and was also president of the Queens Nassau Electric Light & Power Co. He was an original member and former vice-president of the Union League Club in New York. Hart traced his descent directly from John Hart, a signer of the Declaration of Independence.

EMIL G. SCHMIDT, 73, president and executive of many utilities, died at his winter home in Pensacola, Fla., January 4, after having suffered a year from a heart ailment. He held his first utilities job with the Gas, Electric & City Railroad Co., in Sandusky, Ohio. Consolidation of all the privately-owned utilities at Springfield, Ill., was accomplished by him on behalf of an eastern syndicate, and he was named general manager of the system. In 1911 he purchased the Evanston street railway lines which he operated for the West Towns Railroad Co. He built the Des Moines Foundry & Machine Co., at Des Moines, Iowa, and became president of the street car company of Des Moines in 1912. He had been retired since 1919 and had traveled for his health since 1925.

FAIRBANKS-MORSE & Co. has promoted Alan E. Ashcraft from vice-president to vice-president in charge of operations of all Fairbanks-Morse & Co. plants. From headquarters in Chicago, Ashcraft directs operations of plants in Beloit, Wis., Indianapolis, Ind., Three Rivers, Mich., Moline, Ill., Stuttgart, Ark., San Francisco, Calif., and St. Johnsbury, Vermont. A. C. Howard has been named general manager of the Beloit plant, and Charles H. Morse has announced his retirement from the company.



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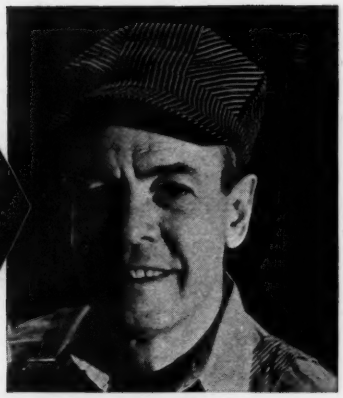

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Inquiries other than domestic, *except those from U. S. Possessions, Canada and Mexico*, should be addressed to ALFLOC LTD., Bush House, Aldwych, London, W. C. 2, Eng. Canadian inquiries should be sent to ALUMINATE CHEMICALS LTD., 372 Bay St., Toronto, Ont.

HORACE G. WILLIAMS has been appointed distribution superintendent of the Chattanooga, Tenn., municipal power system by the Electric Power Board of that city. Williams was formerly superintendent of operations for the Western Division of T.V.A., and prior to that he was connected with the Alabama Power Co. at Tupelo, Miss. Fred Childers of Chattanooga has been made superintendent of substation operation at the municipal plant. He was formerly employed by the Tennessee Electric Power Co. in a similar capacity.

GEORGE W. GRIMM, JR., has been appointed assistant general counsel of Public Service Corp. of New Jersey and subsidiaries. Grimm took over his duties under Counsel Wendell J. Wright January 1. Previously he had served as Deputy State Tax Commissioner in New Jersey.

WESTCHESTER LIGHTING Co. and Yonkers Electric Light & Power Co. have named Clarence L. Law director in their firms. Mr. Law is at present executive assistant to the vice-chairman of the board of Consolidated Edison Co. of New York.

W. D. HUDSON, Clarksville, Tenn., generally known as a "pioneer" in the fight for T.V.A. and municipal ownership of utilities, has been appointed to succeed W. H. Turner of Carthage on the Tennessee Railroad and Public Utilities Commission.

THOMAS A. NEVINS, 69, a founder of the Public Service Corporation of New Jersey, died at a nursing home in New Jersey January 9. He had retired from active work with his brokerage firm 15 years ago. At one time he was president of the Consolidated Gas Company of Newark, founder and president of Newark Telephone Company, and organizer and operator of numerous street railway lines in North Jersey and New York.

PHILIP A. STANG has been elected president and general manager of Keystone Public Service Co. to succeed the late Victor A. Redfield. The board of directors also appointed E. W. York, formerly vice-president, to the post of assistant general manager. No other changes were made. Stang was formerly division manager of the Metropolitan Edison Co. in Lebanon for 11 yr., and prior to that he was with the General Electric Co. at Schenectady, Pittsfield and Baltimore. York has been connected with the Keystone company for 41 yr.

N. PHILIP LORD, 59, production manager of the Spencer Turbine Co., died at the Hartford Hospital in Connecticut January 4. He had been connected with the Turbine company since 1926. His wife, his father, a son and a daughter survive him.

MICHAEL RIESNER, Consulting Engineer for Worthington Pump & Mach. Corp. and an outstanding authority in the field of air and gas compression, died suddenly at his home in Buffalo, N. Y., on December 12. A member of the Worthington organization since 1892, Mr. Riesner served the corporation as chief engineer of its Cincinnati Works for 20 yr. and in this capacity was responsible for several outstanding developments, including a complete line of compressors ranging from the very low capacities up to 36,000 c.f.m.

New Power House for P. & L. E.

SUPPLANTING the Pittsburgh & Lake Erie Railroad's original power house which was placed in operation in 1901, the new $750,000 plant was placed in operation early in January and will furnish electricity, heat, water, compressed air and steam for the railroad's terminal facilities.

Due to the frequent shut downs of the original plant caused by floods, this fact was carefully considered in the design of the new plant. Except for the first floor entrance, which can be completely blocked off in case of flood danger, there are no openings in the new building up to a 50 ft. level. All machinery is housed above this level, making the plant safe from high water to a flood stage of 50 ft.

New Kimberly-Clark Power Plant

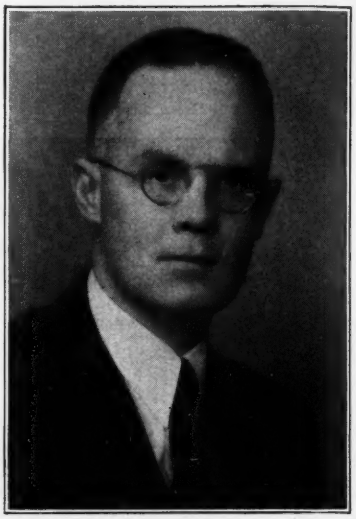
THE KIMBERLY-CLARK CORP., Neenah, Wis., is completing the design of a new steam generating plant and back pressure turbine installation for their Niagara, Wis., mill. It is expected that orders will be placed soon for early delivery of two 900,000 lb. per hr. C. E. Co. 2 drum steam generators for 500 lb. 600 deg. F. The boilers will be fired with Kennedy Van Saun pulverizers, and each will be equipped with a refuse furnace. The turbine generator will be of 2000 kw. 0.80 P. F. capacity, receiving steam at 450 lb. 600 deg. F. and exhausting at 125 lb. 50 deg. F. A complete new boiler house will be constructed, with room for a future third boiler.

Cutler-Hammer, Inc.

CUTLER-HAMMER, INC., Milwaukee, Wis., announces the appointment of E. W. Seeger as chief engineer and P. B. Harwood as assistant chief engineer.

Mr. Seeger became associated with Cutler-Hammer in 1913, shortly after receiving a degree from Ohio State University. During the ensuing 15 yr. he had considerable experience in shop and engineering departments, becoming Assistant Chief Engineer in 1928, a position which he has held to the present time. He is a member of the Engineer's Society of Milwaukee, having served as Director from 1934 to 1936; is a Fellow in the American Institute of Electrical Engineers and Chairman of the Milwaukee Section in 1929; is a member of the Codes and Standards Committee of the National Electrical Manufacturers' Association.

E. W. Seeger



P. B. Harwood

After graduating from Carnegie Institute of Technology in 1917, Mr. Harwood was employed by Cutler-Hammer, entering the company's training course that year. He was shortly transferred to the Engineering Department where he spent several years as a designing engineer. In 1923 he was made Supervisor of the Steel Mill Control Division and in 1928 was promoted to General Supervisor of the Engineering Department. From 1934 to 1936 he was assigned to the development of propulsion control for submarines. He is a member of the A.I.E.E. and an associate member of the A.I.S.E. and the U. S. Naval Institute.

Albuquerque Gas & Electric

ARTHUR PRAGER, vice-president and general manager of the Albuquerque Gas & Electric Co., reports that the $150,000 modernization program started last month at the company's Bernadillo power plant is scheduled for completion in May. In the power plant two 822 hp. Stirling boilers will be rehabilitated and a new 2500 kv-a. condensing turbo-generator will be installed to increase the company's generating capacity from 19,600 to 22,100 kv-a. Wood refuse fuel will be supplemented with natural gas. The power plant was recently purchased from the New Mexico Lumber & Timber Co., which will completely electrify its mill and purchase power to carry the 1400 hp. load.

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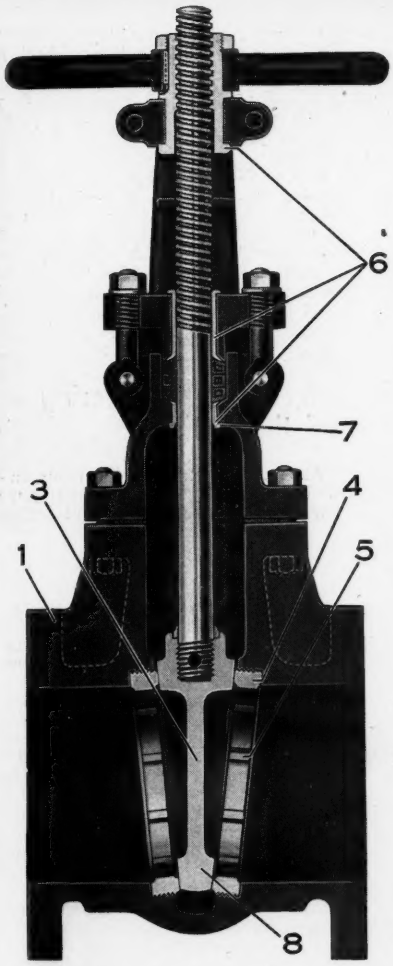

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5. *An ample number of substantial lugs* on seat rings to facilitate renewal.	✓
6. *Bronze bushings* between the bronze stem and iron parts of valve, to prevent corrodible contact and consequent scoring of stem and packing, which causes leaky stuffing boxes.	✓
7. *Back-seat bushing* in bonnet to provide a tight seat for repacking valve in wide open position.	✓
8. *Disc perfectly guided* so that it rides straight and true to its seat without touching seat rings until near the point of closure. To ensure this perfect guiding, the *guide ribs in the body* as well as the guide channels in the disc must be accurately machined.	✓

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Air Conditioning Temperatures

AMONG the important research projects reported by the A. S. H. & V. E. is a determination of the range of temperatures and humidities necessary to provide optimum comfort to the public in summer air conditioning. Expressed in terms familiar to the layman, it was found that the majority of persons in any part of the country are likely to be most comfortable at temperatures between 75 and 80 deg. F. with relative humidities from 30 to 70 per cent.

These findings, following tests extending over a period of 3 yr., provide the industry with definite standards of performance and should do much to eliminate the cause of complaints about over cooling. The findings are the result of controlled tests under actual operating conditions in Toronto, Ontario, Minneapolis, College Station and San Antonio, Texas, Washington, D. C., Pittsburgh and New York city and were participated in by hundreds of human subjects.

Edison Medal to Dugald C. Jackson

DOCTOR DUGALD C. JACKSON, professor emeritus of electrical engineering, Massachusetts Institute of Technology, has been awarded the 1938 Edison Medal of the American Institute of Electrical Engineers, the highest award in electrical engineering.

The award was made to Doctor Jackson "for outstanding and inspiring leadership in engineering education and in the fields of generation and distribution of electric power." The presentation was made on the evening of Wednesday, January 25, during the annual winter convention of the Institute.

Doctor Jackson was born at Kennett Square, Pa., February 13, 1865, and received the degree of civil engineer from the Pennsylvania State College in 1885. He spent the next two years in graduate study in electrical engineering at Cornell University.

His early engineering experience was gained as vice-president and engineer, 1887-89, for the Western Engineering Co., Lincoln, Neb., which was engaged in the design and construction of electric light and power plants and distribution systems. He was assistant chief engineer with the Sprague Electric Railway and Motor Co., New York City, 1889-91, and later was chief engineer for the central district of the Edison General Electric Co., supervising in these positions the design and construction of many electric railway and power plants.

In 1891, he formed a consulting engineering firm with his brother, W. B. Jackson, and also became professor of electrical engineering at the University of Wis., which position he retained until 1907, when he was appointed professor and head of the department of electrical engineering at the Massachusetts Institute of Technology, in which position he notably wove research into the fabric of engineering education.

The consulting engineering firm of Jackson and Moreland, organized in 1919, specialized in the fields of electric power production and distribution of railway electrification with a nation wide and international list of clients. Doctor Jackson continued as senior partner until 1930. He retained his position at the Massachusetts Institute of Technology until 1935, when he retired as professor emeritus.

William Robbins Seigle

AT THE AGE of 59 yr., William Robbins Seigle, chairman of the board of directors, Vice-president and Director of Research of Johns-Manville Corp., died December 26 at St. Mary's Hospital in Rochester, Minn., after having undergone an operation at the Mayo clinic on December 6.

Mr. Seigle, with Johns-Manville for nearly 40 yr., was born at Finesville, N. J. He joined the old H. W. Johns Mfg. Co. in 1899. For the next 5 yr. he worked at almost every job there was in the old Brooklyn plant and soon became an important leader there.

William Robbins Seigle

About that time the company started a program of expansion that called for the purchase of several other manufacturing firms in order to add new products to the H. W. Johns-Manville Co. line. As these concerns were purchased Mr. Seigle was placed in charge of their operation.

In 1916, before the company maintained its own research laboratories, Mr. Seigle organized the Norton Laboratories at Lockport, N. Y., and maintained these as a separate activity for the benefit of the company. The next year he established the W. R. Seigle Laboratories in the garage of his home in New Jersey. When these began to tax the capacity of his home garage, he moved them to a two-story building at Bridgeport, Conn., and this was incorporated as the Fibrefraks Laboratories. In 1928 the laboratories were purchased by Johns-Manville, and all J-M research activities were thereupon centralized at the Manville factory.

In 1917 Mr. Seigle became vice-president of Johns-Manville in charge of factories and mines and became chairman of the board of directors in 1929. At the time of his death he was, in addition, the president of the Asbestos Wood Co. and a director of the Asbestos & Danville Railway.

Surviving are his widow, Mrs. Hilda O. Seigle; four daughters, Miss Vivian Seigle, of Easton, Pa., and the Misses Bruce, Jean and Courtenay Seigle, of Washington; two sons, Alan and William R., Jr., of Washington, and two brothers, Joseph C. Seigle of Bound Brook, N. J., and Clyde N. Seigle of Finesville, N. J.

Westport Station to be Topped

THE CONSOLIDATED GAS, ELECTRIC LIGHT & POWER CO. of Baltimore, Md., has recently let contracts for equipment to top a portion of its Westport Station. The installation will consist of two Combustion Engineering high-pressure boilers of the three-drum bent-tube type supplying steam at 1325 lb. 915 deg. F., at the superheater outlet, to a 25,000-kw. G.E. turbine-generator exhausting to the present 200-lb. turbines. An extension to the present building will house the new equipment.

The new steam generating units will be designed for a maximum rating of 313,000 lb. of steam per hr., with feedwater at 330 deg. F., or 330,000 lb. with feedwater at 383 deg. F. Each unit will be fired by four Type R horizontal turbulent burners receiving pulverized coal, through independent feeders, from two CE-Raymond bowl mills. The furnaces will be completely water cooled and have bottoms of the V-shape dry type. Continuous, fin-tube economizers and Ljungstrom air preheaters will be employed.

Universities, Engineering and the Public

ARICULTURAL RESEARCH in many universities and colleges is supported by the Federal and State Governments while Engineering Experiment Stations have been struggling on without Federal aid, often with little or no support from the state. To emphasize the services that engineering schools have rendered industry, Dean Earle B. Norris of Virginia Polytechnic Institute last year assembled data for the Congressional hearing on the proposed Engineering Experiment Station Bill.

As an outgrowth of this, the Land Grant College Association created a committee on Research and Extension Services to Industry made up of: Dean H. P. Hammond, Pennsylvania State College; Dean R. A. Seaton, Kansas State College; Dean C. E. MacGuiggo, Ohio State College; Dean G. Gilchrist, Texas A. & M. College; Professor L. M. K. Boelter, University of California; and Dean B. R. Van Leer, North Carolina State College. The original intention was to survey all engineering colleges but because of limited time the first committee report, presented at the Chicago meeting of the Association by Dean Van Leer, was limited to Land Grant Colleges.

A summary shows that of 47 institutions reporting, 37 have Engineering Experiment Stations and 36 are doing Industrial research. The cost of this exceeds $1,200,000 annually, takes the part or full time of 766 employees and during the past few years has produced a total of 473 publications especially for industry. Extension services, such as short courses, correspondence courses or institutes are available from 31 of the 47 schools. Many of the courses are self supporting but the annual expenditures for these services are almost $305,000 and they require the part or full time of 583 employees. The heaviest expenditures in each group are made in the seven colleges in New England and the Middle Atlantic States which include M. I. T., Penn State and Cornell.

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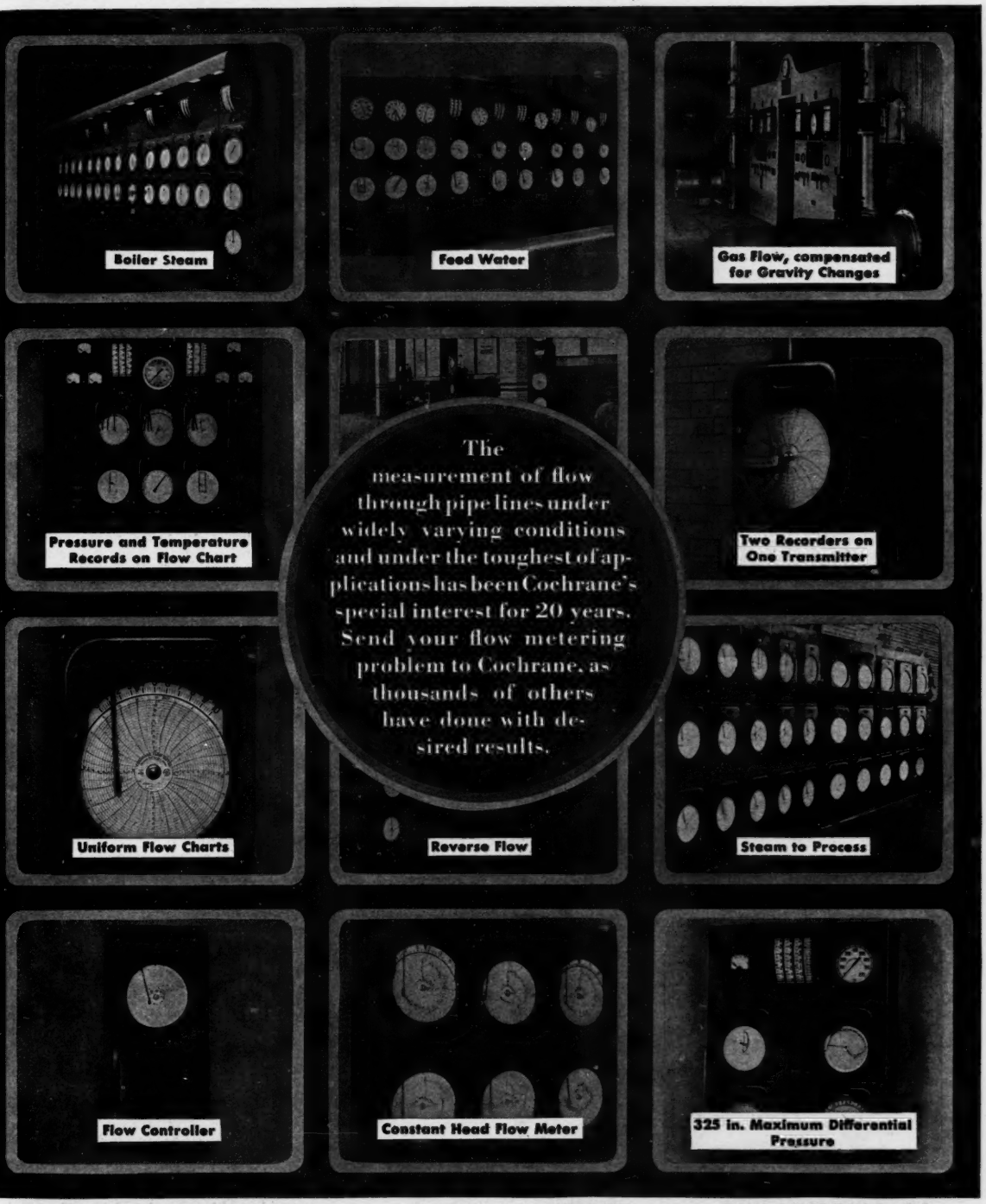
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Boiler Auxiliaries

Stoker—The Detroit LoStoker is a complete mechanical firing unit of the adjustable plunger feed, single retort, side cleaning type. These are built in many sizes and capacities, which are given in a new catalog together with typical application drawings to a wide variety of boiler types. Detroit Stoker Co., Sales & Engineering Offices, General Motors Bldg., Detroit, Mich.

Conveyor—This new catalog contains information about the Hydroveyor, a pneumatic conveyor used primarily to handle fly ash, soot, dust and coal siftings in large industrial plants and central stations. United Conveyor Corp., Chicago, Ill.

Oil Burning Manual of Information is the title of a 4-page leaflet presenting a concise schedule of the various factors that enter into the proper installation and operation of oil burning equipment. Crew Equipment Co., 101 Park Ave., New York, N. Y.

Valves—Bulletins B-420 and B-430, describing Yarway Blowoff Valves for steam boilers, have just been published. These two catalogs replace older Yarway Blowoff Valve literature and completely cover recent changes and improvements in these valves. Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa.

Instruments and Controls

Foster Pressure Reducing Regulators—A new bulletin under this title covers Foster U-Type Pressure Reducing Regulators for air, water, and other gases and liquids. The new catalog contains a description of each of the five types which are designed to cover the widest range of services. The operation of each Regulator is described in detail, and complete instructions are given for dismantling and reassembling. It is designated as Catalog 70, Bulletin 5, and a copy may be secured by writing the Foster Engineering Co., 109 Monroe St., Newark, N. J.

Pressure Reducing Regulators—Bulletin 5 of Catalog 70 describes 5 types of the Foster U Type Regulator gives sizes and applications of each type. Foster Engineering Co., 109 Monroe St., Newark, N. J.

Pressure Indicator—Bulletin 273 and Leaflet 274 illustrate and describe the Premax Pressure Indicator which is approved by the U. S. Navy and leading Diesel manufacturers. Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

Micromax Condensate Purity Instruments for the Steam Plant—A new 20-page illustrated catalog under this title shows how a knowledge of condensate conditions helps to effect important operating economies. It describes a reliable electrical method for continuously determining variations in condensate purity. To receive a copy, ask Leeds & Northrup Co., 4934 Stenton Avenue, Philadelphia, Pa., for Catalog N-95-163.

Instruments—Catalog 48 covers the complete line of 3 and 4 in., round and square, alternating and direct current, ammeters, milliammeters, microammeters, voltmeters, single and polyphase wattmeters and pyrometers. The Roller-Smith Co., 233 Broadway, New York, N. Y.

Instruments—A new broadside, briefly illustrated, describes 13 different types of instruments which are more thoroughly treated in individual bulletins. The number of each bulletin is given, together with the subject treated. Brown Instrument Co., Wayne & Roberts Avenues, Philadelphia, Pa.

Instruments—Frahm Vibrating-Reed Hand Tachometers register speeds as well as rates of vibration merely by being placed in mechanical contact with the machine or apparatus under test. It is illustrated and described in Bulletin 1585. James G. Biddle Co., 1211-13 Arch St., Philadelphia, Pa.

Metals

The Fact Book of Flexible Metal Hose and Tubing—A new booklet under this title presents a complete factual story of these important products while graphically portraying their almost unlimited usefulness in meeting many of industry's most difficult design, construction and maintenance problems. The Flexible Metal Hose & Tubing Institute, 150 Broadway, New York, N. Y.

Safety in Steel is the title of a new 20-page booklet showing what the life industry has done to protect the life and well being of the workers. American Iron and Steel Institute, 350 Fifth Ave., New York, N. Y.

Flexible Metal Hose—Catalog G-14 just issued contains illustrations and engineering data on Rex-Weld corrugated metal hose, Rex-Tube asbestos packed hose and other types, and couplings recommended for each type. Chicago Metal Hose Corp., Maywood, Ill.

Chrome-Alloy Seamless Tubing and Pipe. Technical Bulletin 9, Methods of Working Seamless Tubes and Pipe of Intermediate Grades of B&W Croloys containing chromium, molybdenum, and other alloying elements outlines the proper procedure for fabricating operations. The Babcock & Wilcox Tube Co., Beaver Falls, Pa.

Forging Ahead with Forgings—A new 36-page booklet under this title gives the story of the life of the Steel Improvement & Forge Co., now celebrating its 25th anniversary. The booklet shows the progress made in the design and manufacture of forgings for the past quarter of a century. The Steel Improvement & Forge Co., 960 Addison Rd., Cleveland, Ohio.

Effect of Silicon on Steels—Technical Bulletin 10 is devoted to the effect of silicon on the properties of certain of the most popular chromium-molybdenum steel tubes now being used in quantity by the refining industry. A statement on the influence of copper in steel tubes intended for high-temperature service is also given. The Babcock & Wilcox Tube Co., Beaver Falls, Pa.

Iron & Steel—The 1939 General Catalog provides complete mechanical information on Byers products. It has 56 pages and is wire bound. An index is included which simplifies quick reference. Wrought iron, tubular and flat rolled products and steel tubular products are discussed. A. M. Byers Co., Pittsburgh, Pa.

Kennametal Tools and Blanks are illustrated and described in a new catalog. The catalog gives the basic ingredients of Kennametal and reasons for its desirability in use of tools for turning, boring, facing, milling, keyway cutting and reaming of steel articles. Kennametal No. 2 catalog may be had on request to McKenna Metals Co., 177 Lloyd Ave., Latrobe, Pa.

Steel Panels—Falstrom steel panels are illustrated and described in a new 4-page bulletin just issued by Falstrom Co., Passaic, N. J.

Electrical Equipment

How to Make Cable Joints is the subject of a new 16-page booklet which gives detailed instructions for splicing and vulcanizing all the principal types of rubber-insulated, rubber-jacketed portable cable. Two methods are included. The first, by the use of solder, is generally considered standard. The second describes a method that is particularly well suited to the types of cable used in mines, where soldering is avoided whenever possible. It covers single and two-conductor types of cable. The instructions on vulcanizing apply to both methods of jointing. Copies of booklet GEA-2989 are available on request to the General Electric Co., Schenectady, N. Y.

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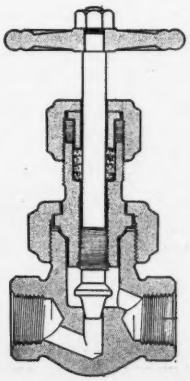
UNION BONNET TYPE

by Vogt



✓ **CHECK HOW MUCH MORE YOU GET** in these new Vogt, union bonnet type, globe Meter Valves . . . available in one-quarter, three-eighths and one-half inch sizes.

- ○ **Hexagon body ends for easy line assembly.**
- ○ **Ground joint between body and bonnet.**
- ○ **Stem can be easily reground or replaced. Valve can be repacked under pressure.**
- ○ **Recommended for 900 lbs. W. P. @ 750 Deg. F. or 1500 lbs. non-shock cold working pressure.**
- ○ **Furnished all-carbon steel or all-stainless steel to suit operating conditions.**

These valves are especially suited for applications in oil refineries, power, chemical, refrigerating and related industrial plants where close, dependable regulation is important.

HENRY VOGT MACHINE CO., Inc., LOUISVILLE, KY.

NEW YORK · PHILADELPHIA · CLEVELAND · CHICAGO · DALLAS

Electrical Equipment—Three new bulletins on the following subjects have just been released: Bulletin GEA-594B is entitled Automatic Control Panels for Industrial Electric Heating. A Full-Voltage Magnetic Motor Starter is the subject of Bulletin GEA-2964. The Metal Enclosed Switchgear is discussed in Bulletin GEA-2872 giving types, applications and voltage and interrupting ratings. It also explains the difference between metal clad and metal enclosed. General Electric Co., Schenectady, N. Y.

Marvels of the Electric Eye is a new 11-page bulletin explaining the principles and technique of photoelectric control, gives a dictionary of commonly used terms, illustrates 11 industrial applications in detail and lists 100 or more applications. Sent to interested readers who will send their name, the name of the firm with whom they are associated and their title to the Electronic Control Division, United Cinephone Corp., 43—33rd St. at Queens Blvd., Long Island City, N. Y.

Modern Lighting Conditioning—A new book under this title has just been published. In the field of industrial light conditioning, the RLM Standards Institute is meeting this demand by establishing standards of efficiency, design and quality for industrial lighting reflectors. The necessity for these standards, what they are and how they may be used to insure proper specification of lighting equipment from both the viewpoint of cost and performance is the subject of the booklet. Into the book has gone the composite experience and knowledge of the engineering departments of the leading manufacturers of lighting reflectors associated in the RLM Standards Institute, 20 N. Wacker Drive, Chicago, Ill.

Mechanical Power Transmission

Mechanical Power Transmission—A 48-page illustrated engineering data book No. 1645 on the Silverstreak silent chain and Silverlink roller chain drives for automotive and stationary engines has just been published. The data contained in this book will be found useful in designing drives for gasoline, oil, Diesel, and steam engines. Link-Belt Co., 519 North Holmes Ave., Indianapolis, Ind.

Speed Control—A new broadside completely illustrates and describes the Reeves Vari-Speed Motodrive. Reeves Pulley Co., Columbus, Ind.

Pumps

Centrifugal Pump—The Worthington Saddle-Mounted Vertically-Split Centrifugal Pump of oil refining service is illustrated and described in Bulletin W.341-B2 just issued by Worthington Pump and Machinery Corp, Harrison, N. J.

Pump Valves and Silent Check Valves are illustrated and described in a new 16-page booklet just issued by the Combination Pump Valve Co., 846 Wyota St., Philadelphia. Pa.

Turbine Pumps—Bulletin W-450-B19C illustrates and describes the Worthington Deep Well Turbine Pumps. Worthington Pump & Machinery Co., Harrison, N. J.

Miscellaneous

Suspended Type Unit Heater—A new bulletin recently published describes the new suspended type unit heater for gas firing. This heater has the unusually large output of 500,000 B.t.u.'s per hour, which, combined with a high velocity, enable the heater to supply warm air to a large area. Copies of this bulletin sent free upon request to Dravo Corp., Lee Heater Division, Pittsburgh, Pa.

Resurfacing Material—Ruggedwear Resurfacer is illustrated and described in a new 4-page bulletin just issued by the Flexrock Co., 23rd and Manning Sts., Philadelphia, Pa.

Printer-Developers—A new, complete and revolutionary line of automatic printer-developers for making white prints is illustrated and described in 3 new bulletins issued by Ozalid Corp., 354 Fourth Ave., New York, N. Y.

Super Thermo-Stucco is the title of a new bulletin which describes a new application of this product by the use of the new Chico Spraying Machine. Chicago Fire Brick Co., 1467 Elston Ave., Chicago, Ill.

New Engineering Books

Compressed Air Trade Standards. Published by the Compressed Air Institute, 90 West Street, New York City. Size 8½ by 11 in., 101 pages; spiral binding; paper cover. Price $1.

Since its inception in 1916, this book has gone through five editions, each more complete and comprehensive than the one before. Since the publication of the Fourth Edition in 1930 the Compressed Air Institute with 22 members has broadened its field of activity to cover other apparatus of various types operated by compressed air as well as air and gas compressors. New sections have been added to cover these fields and the old sections have been completely revised in the light of recent development. Part I covers definitions, nomenclature, standards, guarantees and trade policies, data on tests, installations and care of compressors, lubrication, data tables, and uses of compressed air. Part II discusses and describes in general terms various types of compressors and accessories including rock drills and pneumatic tools.

Transformer Engineering. By L. F. Blume, G. Camilli, A. Boyajian, and V. M. Montsinger. First Edition. 496 pages, 6 by 9, cloth. John Wiley & Sons, Inc., 440—4th Ave., New York, N. Y., 1938. Price $5.00.

The varied and cooperative efforts that have made the writing of this book possible are the result of the association of the authors in the work of the Transformer Engineering Department of the General Electric Co., all of them are members of that department at the Pittsfield Plant of the General Electric Co. This department for many years has been a focus toward which technical problems associated with transformers have naturally gravitated. It goes without saying, therefore, that the book is authoritative, up to date and practical. This volume is quite different from most books on transformers which have been available. It does not contain elementary material easily obtainable elsewhere. Rather, it has been the aim to continue the subject where the college textbooks and handbooks leave off. The primary purpose of the book is to facilitate the solution of the many and various technical problems which confront engineers in the specification, selection, application and operation of transformers. Emphasis has been placed on presenting the essential physics concerned in each problem rather than giving a complete or exact mathematical treatment. Nevertheless, mathematics has been used as freely as seemed necessary for the adequate solution of the various problems. A great deal of practical information is given concerning methods of calculation and properties of transformers. The book is a valuable and useful addition to the literature on transformer technique.

A.S.T.M. Standards on Coal and Coke—After an interval of several years there has just been issued a new revised compilation of all A.S.T.M. standardized methods of testing, specifications and definitions pertaining to coal and coke. This volume includes some 28 standards in addition to a proposed test for agglutinating value of coal. Standard test procedures are given covering such subjects as sampling, fineness, grindability, drop shatter test, tumbler test, screen analysis, size designations and cubic foot weight. The specifications cover gas and coking coals, foundry coke, classification of coals by rank and by grade, and round-hole screens for testing. The definitions pertain to terms relating to coal and coke, gross and net calorific value and varieties of bituminous and sub-bituminous coals. Copies of this 150-page publication, paper binding, can be obtained from A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa., at $1.25 per copy.

Applied Hydraulics. By Herbert Addison. Published by John Wiley & Sons, Inc., New York, N. Y. Size 5½ by 8¼ in., cloth bound, 421 pp. Price $5.50.

The author, Professor of Hydraulics at the Egyptian University, Giza, has revised and enlarged his book originally published in 1934, the principal change being an expansion of the section on dynamic pressure machines and a new chapter on propeller and screw pumps. The book is divided into

RUGGED
FIG. 102
BRONZE GLOBE
VALVE.
POWELL PATENT
200
WHITE
WSP
SEAT
FIG. 375
BRONZE GATE
VALVE.
POWELL
PAT.
WHITE
200
WSP
FIG. 150
BRONZE GLOBE
VALVE.
POWELL
UNION
RUGGED VALVE
CONSTRUCTION
IS ESPECIALLY DESIR-
ABLE TO THE ENGINEER.
IT MEANS WITHSTANDING
ABNORMAL WORKING CON-
DITIONS - - - YEARS OF
SAFE, TROUBLE-FREE
VALVE PER-
FORMANCE
Specify
POWELL VALVES
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three parts, the first dealing with fundamental principles, the second with practical applications and the third with some 125 examples and their solutions. These last must be considered as an integral part of the book, illustrating points, which for brevity were not fully developed in the main body of text.

Although written primarily as a text book for college students, both those taking a general course and those specializing in some phase of hydraulics, the needs of the practicing engineer have been kept in mind, particularly in the second part of the book dealing with applications.

For the American engineer one of the valuable features is the numerous equipment views and examples representing European practice, thus giving a direct comparison with contemporary American design. The text is divided into 16 chapters, 10 dealing with practical applications such as: pipe and pipe systems; flow in open channels; turbines; pumping machinery; automatic control devices; transmission and storage of energy; and hydraulic measurements.

Engineer's I. Q. Test, 22 pages, paper, 5 by 7 in., 1938. National Association of Power Engineers, 176 W. Adams St., Chicago, Ill. Price 10 cents.

Based on the "true or false" idea, this test gives 120 statements on engineering and scientific principles and facts by which the reader may test the accuracy of his knowledge. Correct answers and the reasons therefor are given at the back of the book. It gives an interesting exercise and test of one's understanding of such matters and is part of the educational program of N.A.P.E.

Advanced Mathematics for Engineers. By Harry W. Reddick and Frederic H. Miller. 6 by 9 in., cloth, 471 pages; 1938. John Wiley & Sons, Inc., New York, N. Y. Price $4 net.

This is a book for students and readers who have had mathematical traiping, through calculus, and want further knowledge as to solving of differential equations. It deals with problems relating to hyperbolic functions, elliptic integrals, infinite and Fourier series, Gamma and Bessel functions, partial derivations and differential equations, vector analysis, probabilities, functions of a complex variable, operational calculus. As will be seen from these titles, it is a book for "advanced" engineers who need the use of these methods in their work. Problems to which the methods discussed are applicable include: heat flow; resistance of complex electrical circuits, deflection of beams, periods of vibration and oscillation, design of weirs, flow of fluids, probable errors of observations, areas of irregular shapes, analysis of electrical networks.

For those interested in the use of higher mathematics, the book gives a comprehensive treatment of the applications of differential and integral calculus and their expansions to the solution of complicated physical and engineering problems.

Theory of Mechanical Refrigeration. By N. R. Sparks. Published by McGraw-Hill Book Co., 330 West 42nd St., New York, N. Y. Size 6 by 9 in., 225 pp., cloth bound. Price $3.00.

The author assumes on the part of the reader, a reasonably thorough knowledge of engineering thermodynamics but realizes, from his work as Associate Professor of Mechanical Engineering at the Pennsylvania State College, the natural lapse usually suffered by those who have been out of contact with the subject for some time. He has, therefore, devoted a chapter to a brief review.

This book was prepared with the object of confining the content solely to that necessary for a thorough presentation of fundamental thermodynamics to the subject of refrigeration. This has been vigorously adhered to, the method of approach provoking clear and logical thinking. Occasionally he dwells at some length upon details which may appear to be of little immediate importance but which are in reality an important part of the foundation.

The book is designed for general use, as a text demonstrating the application of the fundamentals. The study of refrigeration cycles and systems is complete, providing excellent examples of applied thermodynamics, for compression, absorption, adsorption and water vapor systems.

Heat Transfer and Pressure Drop in Heat Exchangers. By Byron E. Short. Published as Bulletin No. 3819 by the Bureau of Engineering Research, College of Engineering, The University of Texas, Austin, Texas. Size 6 by 9 in., paper bound, 39 pages. No charge.

Results and data of a series of experiments with water and several grades of oil in a shell-and-tube heat exchanger are presented in graphical and analytical form. The heat exchanger was tested without baffles, with various types of baffles, and with different tube spacing in order to determine the effect of pressure loss in tube bundles and the effect on heat transfer. Comparison with other work shows that the methods used are applicable to units of other heater lengths and diameters.

Oxyacetylene Welding. Original book by Robert J. Kehl (1917) revised by Morgan H. Potter. Published by the American Technical Society, Drexel Ave. at 58th St., Chicago, Ill. Size 5½ by 8½ in., cloth bound, 125 pp. Price $1.25.

As a practical manual on oxyacetylene welding, hard surfacing, lead burning and cutting, this book has been well done. It is clearly but briefly written, well illustrated and reflects the experience of the revising author as instructor in welding at the William Hood Dunwoody Industrial Institute in Minneapolis. The process and theory are introduced briefly and the balance of the book is devoted to the practical technique of welding steel, cast iron, malleable iron, bronze, copper, aluminum and white metal. Silver soldering, hard surfacing, cutting and lead burning are treated in detail and the final pages deal with the design of jigs and costs of welding.

Air Conditioning. By James A. Moyer and Raymond U. Fittz. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y. Size 6 by 9 in., cloth bound, 423 pp. Price $4.00.

Theory and practice are well balanced in the new edition of this book first published in 1933. In addition to the general selection and operation of equipment for a wide variety of applications, detailed treatment is given to specific applications such as office buildings, theatres, residences, restaurants, food factories, textile mills, railroad cars. Additional data on sun effect, heat transmission through building materials and data on unit air conditioners is included in the new edition. Some 57 practical air conditioning problems, together with a selection of useful tables and charts are included in the back of the book. The authors are State Director of University Extension in Massachusetts, and, Assistant Professor of Mechanical Engineering, Tufts College, Boston, respectively.

Edison Electric Institute, 420 Lexington Ave., New York city, has recently issued six publications, all paper bound, trimmed to 8½ by 11 in. The cost indicated on each publication refer to E. E. I. members and their employees; to non-members in the U. S. A., and to non-members in foreign countries, respectively.

No. F8, of 9 pp., is Test Specifications for Automatic Electric Storage Water Heaters and intended to establish a procedure to make possible the determination of the performance in terms of safety, effectiveness, durability and convenience. Prices: 20 ct.; 50 ct.; and 60 ct.

No. F9, of 82 pp., is a report of the Transmission and Distribution Committee dealing with conductor sags and tensions for rural lines. The report is largely in the form of a chart and explanatory notes, intended for use in connection with the design of rural lines to obtain proper clearances to ground, track rails and conductors of other circuits. Prices: 40 ct.; $1.00; and $1.10.

No. F10, of 9 pp., is on Tree Trimming Practices with safe practices, suggestions for field work and photographic examples of proper pruning and trimming of trees so as to clear overhead lines. Prices: 20 ct.; 50 ct.; and 60 ct.

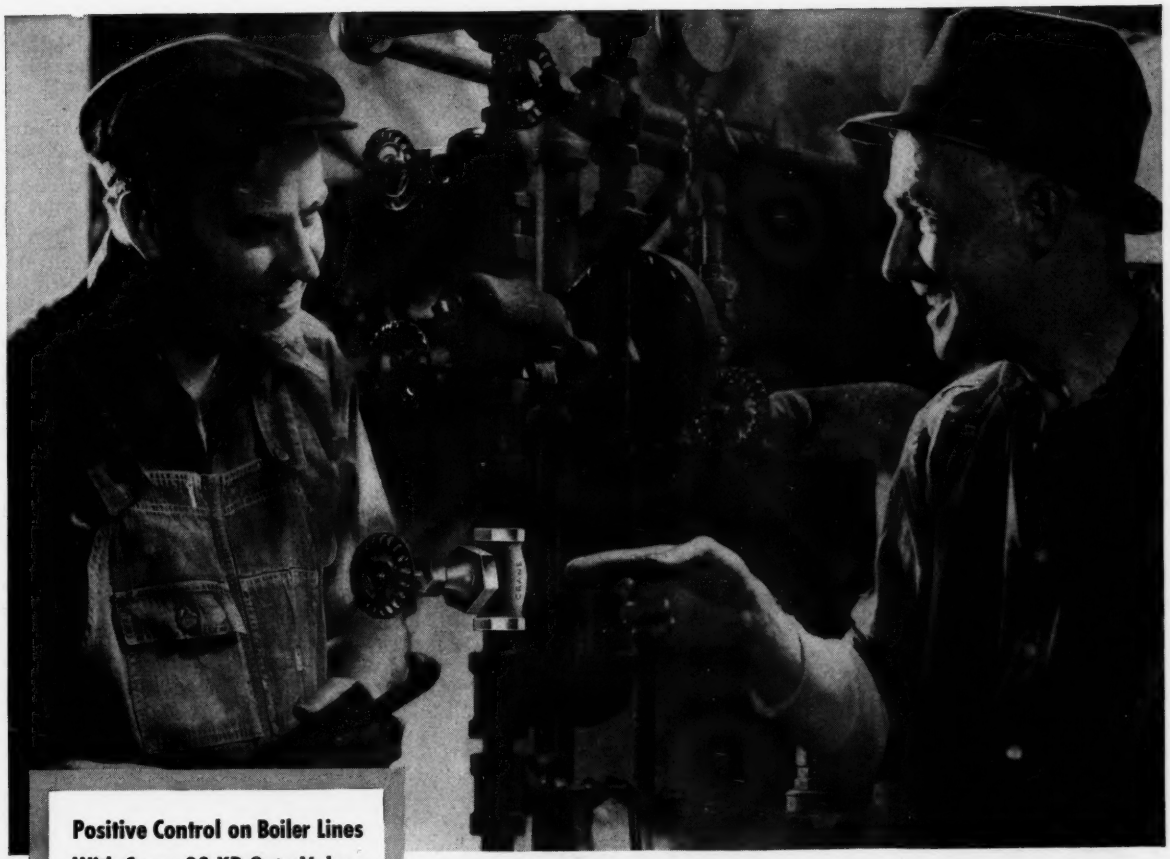
No. F11, of 16 pp., is on the subject of Electrification of Oil Refineries and gives data on the use of electric drive in various locations in oil refineries and comparative performance with mechanical power drive. Prices: 30 ct.; 75 ct.; and 85 ct.

No. F12, of 67 pp., Combustion is a report of the Combustion Subcommittee of the Prime Movers Committee and contains statements by operating companies and manufacturers on pulverized fuels and furnaces; stokers, mechanical draft equipment; fly-ash collectors and ash handling and combustion control. Prices: $1.00; $2.50; and $2.65.

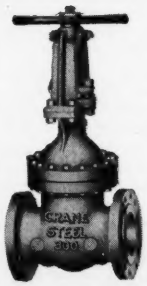
No. F7 Economical Distribution Transformers Loading and Thermal Performance of Distribution Transformers is the report of the Overhead Distribution Group of the Transmission and Distribution Committee. Prices: 40 ct.; $1.00; and $1.10.

How to Operate Under the Wage and Hour Law. By Feller and Hurwitz. 248 pages, cloth bound. The Alexander Publishing Co., Inc., New York, N. Y. Price, $3.50.

This book has been written from a layman's point of view to deal objectively with the problems raised by the new wage law, and to suggest definite rules for meeting the law's requirements effectively and economically.



Positive Control on Boiler Lines With Crane 33 XR Gate Valves



For safety's sake you must have sure control in handling 300 pound steam at temperatures around 750° F. That's why Crane makes these No. 33 XR cast steel gate valves for boiler lines. Take boiler feed service, one of the toughest jobs boiler room valves must do—yet Crane Quality in the 33 XR's assures you of dependable action, tight and true in cutting out water feed pumps and water heaters. And they're just as reliable for boiler leads. Whether your process lines go on and off every day or month, when you turn the wheels of these Crane steel valves, they'll respond smoothly—with positive flow control.

"HERE'S ONE THE STOCKHOLDERS OUGHT TO LIKE"

MEN who buy or use valves are obviously familiar with them. That very fact, however, may lead to oversight of the fine shades of quality in valve design and construction. A valve may seem like a small item—the loss caused by an inefficient one, small too. But multiply this loss by the hundreds, perhaps thousands of valves on your pipe lines and the aggregate may easily affect the profit and loss statement.

Crane valves are engineered to stop even the small losses. The extreme accuracy of their manufacture and the careful analysis and specification of the materials that go into each part assure long, economical service and few time-wasting replacements.

Regardless of what your piping problem may be—regardless of how specialized your field—you will find the valve you want in the complete Crane catalog which includes more than 38,000 items. Consult the Crane representative regarding valves and fittings to meet your particular requirements.

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NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

Analysis of present-day interpretations of Interstate Commerce presents the current theory of "industrial integration" in simple language so that any employer can determine whether or not he comes under the jurisdiction of the Commerce clause.

Among important points brought out is the matter of interlocking responsibility which the law has set up to make the handler of "substandard" goods equally liable with the original producer or processor who violated the law; so that an interested person can use an alleged wage-hour violation as a pretext for legal action aimed at prohibiting a manufacturer or processor trom selling or distributing his products.

The authors explain that employers who fail to "play ball" with a warring labor union may easily find themselves confronted not only with a strike within their plant but also with a court order preventing their customers from handling or shipping the plant's products.

Official text of the Fair Labor Standards Act has been included together with latest official rulings and regulations, with tabulation of pertinent decisions relating to the Interstate Commerce provisions of the new regulations.

For quick reference regarding the law's provisions an excellent outline of major problems and their solution is given in a Syllabus in question and answer form.

By making clear the underlying premises of the present legislation, the book becomes useful as a foundation for forecasting the probable course of this far-reacihng labor law.

Pattern Making. By James Ritchey, revised by Walter W. Monroe, Charles Wm. Beese and Philip Ray Hall. Published by the American Technical Society, Drexel Ave. at 58th St., Chicago, Ill. Size 5½ by 8½ in., 230 pp., cloth bound. Price $2.00.

A practical book on pattern making, including woodworking and wood turning, tools and equipment, construction of simple and complicated patterns, modern molding machines and molding practice. The last third of the book is devoted to metal pattern making.

Forging Practice. By Carl G. Johnson. Published by the American Technical Society, Drexel Ave. at 58th St., Chicago, Ill. Size 5½ by 8½ in., cloth bound, 130 pp. Price $1.50.

The ancient and honorable art of blacksmithing has changed of recent years, broken into a dozen different branches of forging, rolling, piercing, pressing, drawing and extruding. The introduction of alloys has further broadened the need for a working knowledge of metallurgy and intensified the importance of heat treatment for annealing, hardening and tempering. The author, assistant professor of mechanical engineering at Worcester Polytechnic Institute, has covered these in a practical and concise manner, sufficiently ample to meet the needs of those with an interest in forging either as a phase of modern manufacturing or as a user of the finished product. For the average power plant engineer, however, the most interesting section is the 20 odd pages dealing with blacksmithing, hand and small hammer forging, forge welding, etc., for the production of hand tools. Those with a forge and anvil available will find this section valuable either as an avocation or as a practical method of making odd tools and parts. A final section deals with the identification of steel by different tests including the sparks thrown off by a grinding wheel.

Steel Products Manual, Section 4, is a 19-page, 6 by 9 bulletin published by the American Iron and Steel Institute, 350 Fifth Avenue, New York City. This section covers Rolled Steel Structural Sections, describes the manufacturing process, standards and specifications. It is sold by the Institute at 15 cents a copy.

Symposium on Impact Testing— The Symposium on Impact Testing, held at the 1938 A.S.T.M. annual meeting, concentrated on two of the most important phases of the subject, first, the present fields of commercial use for the impact test with particular reference to places where it gives necessary information not supplied by static tests, and second, the basic theory of the test. Nine extensive technical papers and discussions comprise the 170-page symposium book. Copies in heavy paper cover are available from A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa., at $1.25 per copy.

Steam Engine Principles and Practice. By Terrell Croft. Second edition revised by E. J. Tangerman. Published by the McGraw-Hill Book Co., 330 W. 42nd Street, New York, N. Y. Size 5 by 8 in., 487 pp., cloth bound. Price $3.50.

As one of the popular Croft Power Plant Series, the original edition of this book is probably the best known practical steam engine book published. Inasmuch as no attempt was made to include engine design, the general content is as useful today as it was when first compiled in 1922. The steam engine continues as an extremely popular prime mover and the present edition amplifies the book in accordance with modern practice. Data on newer engines have been added, corrections made and tables corrected and amplified in accordance with current practice. The original arrangement and purpose "to enable the reader wisely to select, operate, care for and repair steam engines . . . " has been retained. Mathematics beyond arithmetic are not required and solutions to the problems following each chapter are given in an 8 pp. appendix.

Chemical Tables from the handbook of Chemistry and Physics. Editor in Chief Charles D. Hodgman. First Edition. 1400 pages, 5 x 7¼ in., bound in fabrikoid. Published by The Chemical Rubber Publishing Co., 1900 W. 112th St., Cleveland, Ohio, 1938. Price $2.50.

This is a compilation of tables taken from the Handbook of Chemistry and Physics. The Handbook of Chemistry and Physics in its succeeding editions has grown to a volume of over 2000 pages. In view of the increasing size of this handbook it has been deemed advisable to issue a separate volume of Chemical Tables, taken from the older Handbook. This new volume includes not only tables found in the Handbook but many new ones and all have been brought up to date.

Electrical Machinery. By F. A. Annett. Second edition, cloth, 429 pages, 6 by 9, 494 illustrations. McGraw-Hill Book Co., Inc., New York, N. Y., 1938. Price $3.00.

This new edition of Mr. Annett's book forms a welcome addition to practical electrical literature. It constitutes a whole home-study course in electrical engineering that should be of value to every practical man in the field. It plainly fits theory to practice, for electricians, power plant men, and all who work with generators, transformers, motors, etc. Beginning with a discussion of the very first fundamentals of electricity and magnetism, it develops every step in theory and application. The many practical examples given together with their complete mathematical solution should make jobs of installing, operating and maintaining electrical machinery less complex.

This book was first published 17 years ago but since that time vast changes have been made in electrical machine design, construction and applications and even though a large part of this text is fundamental, a revised edition is justified to bring the treatment into accord with present-day practice and to include new material. Since the first edition, for example, electron tubes and mercury arc rectifiers have come into extensive use and the new chapter dealing with this phase of electrical engineering is a valuable addition to the book. In all, about 100 pages of new material has been added.

Proceedings 1938. Published by the National District Heating Association, 1317 Spruce St., Philadelphia, Pa. Size 6 by 9 in., 315 pp., cloth bound. Price $5.00.

Official proceedings of the 29th annual convention of the Association at Baltimore, June, 1938, including the addresses and annual reports of thirteen committees. The report of the distribution committee covers more than 80 pp. and includes a detail cost analysis of a hypothetical 400 ft., 12 in. steam line by 9 different companies. Operating statistics of the industry occupy 25 pp.; station engineering problems 38 pp.; commercial relations, customers' problems, sales, meters and accessories 75 pp.; research, mosthly steam jet refrigeration and smoke stack corrosion, 21 pp. The balance is devoted primarily to association business, a list of members and committee personnel.

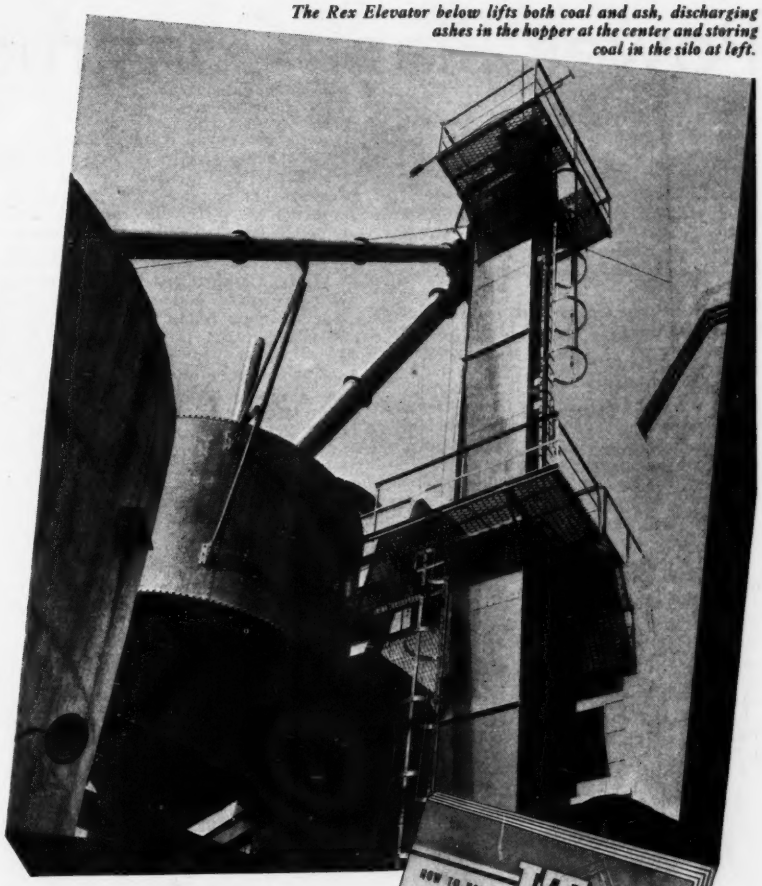
Foundry Work. By William C. Stimpson and Burton L. Gray, revised by John Grennan. Published by the American Technical Society, Drexel Ave. at 58th St., Chicago, Ill. Size 5½ by 8½ in., 214 pp., cloth bound. Price $2.00.

In this revised edition, molding practice, including the many questions of pattern construction which are more or less closely associated with foundry work, is fully discussed. The presentation includes a number of typical molding problems and covers the uses of various types of molding machines which have become popular within the last few years. Casting operations, including materials, melting and pouring equipment, metallurgy of cast metals, non-ferrous castings, and all other operations dealing with casting are thoroughly and carefully explained from a practical standpoint.

HOW TO HANDLE IT

IF *IT* IS POWER PLANT COAL AND ASH

The Rex Elevator below lifts both coal and ash, discharging ashes in the hopper at the center and storing coal in the silo at left.



It is not necessarily a hard job to raise the efficiency of your boiler room! It may be merely a matter of selecting and combining properly one or more Rex coal and ash handling units and adapting them to your specific needs.

That was the case in this by-product plant where a mediocre handling system was eating too many operating dollars. After Rex Power Plant Equipment Engineers were called in, standard units from the Rex line were combined to give new life, new smoothness and economy to their coal supply and ash removal system.

Coming to the aid of the power plant operator with money-saving conveyors is a 40-year-old habit of the Chain Belt Company—a habit which can be a real help to you. Take advantage of it.

SEND FOR NEW BOOK!

Here's real help for you in the selection and proper combination of the units to make up your coal and ash handling system: the new book "How to Handle It with Rex Coal and Ash Handling Equipment." Use this coupon to get your copy.

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☐ Please send me my copy of "How to Handle It with Rex Coal and Ash Handling Equipment."

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*City*_____ *State*_____

REX COAL HANDLING EQUIPMENT

CHAIN BELT COMPANY of Milwaukee

Power Plant Construction News

Ariz., Tucson—Water Department, Tucson, plans early call for bids for motor-driven pumping equipment for booster stations to be built on First and Cherry Avenues, respectively. Also for new elevated steel tanks at Elm Street and Third Avenue. Cost reported about $125,000. Philip Martin is superintendent.

Calif., Los Angeles—Los Angeles Brewing Co., 1920 North Main Street, plans installation of power equipment in proposed new additions to plant, comprising several one and multi-story units. Project is scheduled to be carried out this year. Complete program will cost about $500,000. L. A. Parker is company engineer.

Conn., Hartford—Hartford Electric Light Co., has authorized an appropriation of about $1,000,000 for expansion and improvements in power plants and system during 1939, and will proceed with project at early date.

Ill., Rock Island — International Harvester Co., 180 North Michigan Avenue, Chicago, Ill., plans intallation of electric power equipment in connection with expansion and improvements in tractor works at Rock Island, including construction of several new units. Cost close to $5,000,000. Work will be carried out in 1939.

Ill., Rock Island—Peoples Power Co., Moline, Ill., plans extensions and improvements in power plant at Rock Island, including installation of new boiler units and accessories, and other equipment. Cost estimated over $250,000. Proposed to carry out work this year.

Ind., Laporte—E. M. Laird Airplane Co., 5917 South Cicero Avenue, Chicago, Ill., plans installation of electric power equipment in new aircraft-manufacturing plant at Laporte, where site is being selected. Entire project is reported to cost close to $60,000.

Iowa, Sibley—Town Council will receive bids until Feb. 8 for extensions and improvements in municipal electric power plant, including 750-kw. steam turbo-generator unit and accessories, surface condenser, cooling tower, switchgear, etc. Cost close to $150,000. Young & Stanley, Inc., Muscatine, Iowa, is consulting engineer.

Kan., Kansas City—City Council has approved plans for one-story cold storage and refrigerating plant, 140x360 ft., in public levee district, and will begin work soon. Cost over $175,000, including equipment. Joseph W. Radotinsky, Commercial National Bank Building, Kansas City, Kan., is architect; Walter F. Schulz, Shrine Building, Memphis, Tenn., is consulting engineer.

Kan., Ottawa—City Council will take bids soon for extensions and improvements in municipal electric power plant, including two new boiler units with capacity of 50,000 lb. steam per hour, each, and auxiliary equipment. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

Md., Baltimore—Consolidated Gas, Electric Light & Power Co., Lexington Building, is arranging fund of about $2,700,000 for expansion and improvements in power plants and system during 1939. Work is being started on new addition to steam-electric generating station at Westport, to increase present capacity by 33,000-hp., estimated to cost close to $3,500,000, in addition to amount noted. Completion is scheduled in 1940.

Minn., Cambridge—Village Council has had survey and estimates of cost made for new municipal electric light and power plant, totaling about $200,000. Proposed to use Diesel engine-generating units and accessory equipment. Work is scheduled to be carried out in spring. Ralph D. Thomas Associates, 1200 Second Avenue South, Minneapolis, Minn., are consulting engineers.

Minn., Halsted—City Council is making surveys and estimates of cost for new municipal electric power plant and electrical distributing system. Proposed to arrange financing soon. G. M. Orr & Co., Baker Arcade Building, Minneapolis, Minn., are consulting engineers.

Minn., Pine River—Common Council plans extensions and improvements in municipal electric power plant, including installation of new engine-generator unit and auxiliary equipment. Estimates of cost are being made. G. M. Orr & Co., Baker Arcade Building, Minneapolis, Minn., are consulting engineers.

Mo., Jefferson City—State Building Commission, Bi-Partisan Advisory Board, Merchants' Bank Building, Edgar M. Eagan, acting secretary, will receive bids until Feb. 7 for combustion control equipment and boiler instruments for installation in power houses at institutions at Fulton, Nevada, Farmington, Marshall and Mount Vernon, Mo. Charles A. Haskins, Finance Building, Kansas City, Mo., is general supervising engineer.

N. J., Belleville—Andrew Jergens Co., 2535 Spring Grove Avenue, Cincinnati, Ohio, plans installation of electric power equipment in new plant for soap and toilet preparation-manufacture on Mill Street, Belleville, where large tract of land is being secured. A power house will be built. Entire project is reported to cost about $1,000,000.

N. J., Burlington—Public Service Electric & Gas Co., Public Service Terminal, Newark, N. J., has authorized expansion in steam-electric generating station at Burlington, including installation of a new 100,000-kw. turbo-generator unit, high-pressure boilers and auxiliary equipment. Entire project will cost about $12,000,000 and is scheduled for completion in 1940.

N. Y., New York—Consolidated Edison Co. of New York, Inc., 4 Irving Place, has taken out a permit for alterations and improvements in six-story steam-electric generating plant at 686-700 First Avenue, estimated to cost about $40,000, exclusive of equipment.

N. D., Ellendale—State Board of Administration, Bismarck, N. D., A. B. Welch, executive secretary plans new steam power house at state normal school at Ellendale. Cost close to $40,000. Financing is being arranged through a state appropriation. Ritterbush Brothers, 209 Seventh Street, Bismarck, are architects.

N. D., Wahpeton—Otter Tail Power Co., Fergus Falls, Minn., plans extensions and improvements in Kidder steam-electric power plant at Wahpeton, including installation of a new 10,000-kw. turbo-generating unit and auxiliary equipment. Cost about $400,000. Project scheduled to be carried out in 1939.

Ohio, Cleveland—Eaton Mfg. Co., 739 East 140th Street, plans installation of electric power equipment in new one-story addition, 40x342 ft., to automobile parts-manufacturing plant. Work will begin soon. Entire project will cost over $100,000. George S. Rider Co., Terminal Tower Building, Cleveland, is architect and engineer.

Ohio, Middletown—City Council has plans nearing completion for new municipal electric light and power plant. Erection is scheduled to begin early in the spring. Awards for equipment will be made soon. Cost over $1,700,000. Froehlich & Emery Engineering Co., Second National Bank Building, Toledo, Ohio, is consulting engineer.

Okla., Tulsa—Bethlehem Supply Co., National Bank of Tulsa Building, plans installation of electric power equipment in connection with extensions and improvements in local oil well machinery-manufacturing plants of International Supply Co., and Oklahoma Iron Works, Inc., West Archer Street, recently acquired. Entire project will cost close to $500,000. Company is a subsidiary of Bethlehem Steel Co., Bethlehem, Pa.

Ore., Portland—Chase Bag Co., 155 East Forty-fourth Street, New York, N. Y., plans installation of electric power equipment in new branch paper bag-manufacturing plant at Portland, for which superstructure will begin soon. Entire project will cost about $100,000.

Pa., Reading — Textile Machine Works, Inc., plans installation of electric power equipment in new one-story addition to textile machinery-manufacturing plant. Entire project will cost about $100,000. Work will be placed under way at early date.

Texas, Corpus Christi—Col-Tex Refining Co., Oklahoma City, Okla., plans installation of power equipment in new asphalt-blending plant at Corpus Christi where site has been selected. Project will include a power house and pumping station. Complete plant is estimated to cost over $1,200,000. Proposed to begin work soon.

Texas, Dallas — Vanette Hosiery Mills, 6001 Maple Street, plan installation of electric power equipment in new addition to knitting mill. Entire project will cost over $200.000. Proposed to begin work soon. Joseph O. Davis is president.

Texas, Texarkana—City Council has plans under way for new municipal electric power plant. Cost estimated close to $545.000, of which $300 000 will be secured through Federal aid. Proposed to begin work soon.